JOURNAL

OF THE

FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA.

FOR THE

PROMOTION OF THE MECHANIC ARTS.

VOL. LXI.] MAY, 1871. [No. 5

EDITORIAL.

ITEMS AND NOVELTIES.

Boiler Explosions.—In Prof. Thurston's able paper, continued in our last number, allusion is made to the good effects of the steam boiler inspecting and insurance companies of England, and to the marked benefits which had resulted from their labors. We see in the last number of the *Mechanics' Magazine* that, in the report of the Manchester Steam User's Association for 1870, which has just been read, it appears out of 2116 boilers under inspection, no explosion has occurred, while of boilers not under inspection, 51 have exploded, killing 78 persons and injuring 106 others. It is certainly high time that this preventable loss of life and limb should be arrested.

In further illustration of the fact that even in popular estimation boiler explosions are beginning to be recognized as the result of preventable conditions, and are no longer to be regarded as inevitable

disasters of mysterious origin, we quote from the *New York Times* the following remarks:

"The explosion of a steam boiler is *prima facie* evidence of carelessness in its construction, or in its use. It is so regarded by the engineers, and ought so be regarded by the law. It will be easy to convince any one who will examine the records of boiler explosions and inquire into the means of preventing them, that no injustice would be done to the owners of boilers by indicting them for criminal carelessness in all cases of explosion.

"The history of boiler explosions is authentic and definite. The boiler has usually been erected under the full light of modern science. All the attending circumstances of the explosion have been immediately communicated to the public; curiosity has aided science in making every man an investigator of these circumstances and a searcher after causes; public and private commissions have been appointed to examine the subject generally; numerous legal tribunals have gone to the bottom of special cases, and innumerable private professional observers have witnessed results, searched records, weighed evidence, and arrived at general conclusions. All the plausible theories of explosions have been not only looked into, but worked out, in many cases, experimentally or theoretically, to their ultimate limits.

"Now, the remarkable and unprecedented result of all this investigation is, not the division of any large body of experts into schools; not the building up of rival theories, but the universal conviction of all concerned, that boiler explosions are certainly in most, and probably in all cases, the result of malconstruction or maltreatment, and of nothing else, and that the usual immediate cause is the unchecked deterioration of the boiler in service. In the great majority of cases the evidences of carelessness are as plain as the time of day on the face of a clock—a sheet furrowed nearly through; a stay bolt rusted off; a crown-sheet insufficiently supported; expansion and contraction unprovided for; water connections stopped up; bad material—some one of the many obvious and certain conditions of rupture. In a few cases the immediate causes are not apparent, and then the electricity theorists, and the gas people, and the mystery men fight over the remains in the newspapers; and the only reason why simple neglect is not discovered to be the cause, is that the parts of the boiler which would otherwise reveal it, are blown away, or are too much mutilated or obstructed to be legible. Sim-

ple bad treatment by the maker or user will account for the original rupture which ends in any explosion, however terrific may be its effects. There is force enough restrained within every steam boiler running to-day to perform the most terrible work of ruin that any similar boiler ever performed in exploding. When this force is once released, the amount of destruction depends on the point of rupture, the resistance, the surroundings, and on an infinite number of circumstances, mostly outside of our control. The only thing we can do, and it is enough, is to keep the resistance superior to the normal pressure.

"Now that the causes of boiler explosions are so well understood as to be a matter of commercial calculation—where companies make money by insuring such boilers as are constructed and maintained according to established professional rules—it is to be regretted that the government should stand helplessly by, and see scores of people scalded to death every few weeks, for the want of an adequate law and a system of inspection. Boiler insurance and inspection companies—and they are no new or experimental thing—simply prove that boilers constructed and maintained according to certain well known rules, are practically safe; that the chances of explosion, even with ordinary water-tending, are very remote, and they stake their money on this knowledge; and yet the United States Government has been unable to check the increase of these disasters. If Congress cannot at once provide for the security of the public against boiler explosions, it had better let out the job of protecting its citizens to some insurance company, and then it will be done on scientific principles, and by competent men."

Steam Boiler Inspection.—The second annual report of the Inspector of Steam Engines and Boilers for Philadelphia, which has reached us through the kindness of the editors of the *Sunday Times*, affords, in connection with the preceding item, additional matter for reflection. We learn from it that during the year 1870 there were upwards of one hundred disastrous explosions of steam boilers in the United States, by which three hundred and twenty-six persons were killed, and two hundred and twenty-seven wounded. Those who were instrumental in calling this Department into existence should be gratified when they are informed that, during the same year, although there were at least two explosions every week in various parts of the United States, of which New York, Baltimore, Brooklyn and Chicago had their respective shares,

none occurred in the city of Philadelphia, notwithstanding the fact that it has a greater number of boilers than any other of the above mentioned cities.

The following paragraph, embodying some excellent views on the qualifications of engineers, is worthy of the widest publicity:

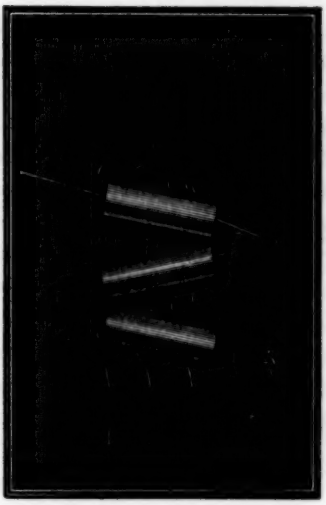
"The bill recently introduced to the Legislature, requiring persons in charge of stationary steam engines in this city, to pass an examination before a competent Board, is a very proper movement, and should receive favorable consideration. The present bill may not be all that is desired in its provisions, but in principle it is correct, and the mere details of the bill can be so amended as to give us a law that will be satisfactory in its construction and beneficial in its operations. A man in charge of a stationary steam engine, driving machinery requiring the labor and attention of hundreds of industrious operatives, has a vast responsibility, involving life and property, and should be required to demonstrate his fitness and capacity for the duties of an engineer. It frequently happens that men are employed as engineers who have no idea whatever of the mechanical intricacies of an engine, and whose knowledge of machinery does not extend beyond the lever by which its motion is regulated. Some trifling defect, which an educated mechanic would instantly perceive and immediately correct, might be permitted to pass without notice by an inexperienced and ignorant person, and result in a terrible catastrophe. In many cases the owners of mills and factories regard the amount of wages to be paid for running the engine as the primary consideration, and never give a thought to the hundreds whose lives are thus wantonly exposed to his cupidity and his engineer's ignorance. The public cannot be too securely guarded against the dangers by which they are constantly threatened through the employment of ignorant and incompetent men as engineers."

The Mont Cenis Tunnel.—One of the most difficult of modern engineering undertakings is now practically finished, and a review of the work accomplished will give a general idea of its magnitude.

Mont Cenis, through which the tunnel has been bored, is, at its most elevated point, about 12,000 feet in height, and separates the French province of Savoy from Piedmont in Italy. The tunnel is very nearly 8 miles in length, its width is 25 feet, and height 24 feet. The character of the rock through which borings have penetrated was variable in different parts—consisting of schist, quartz and limestone; mainly, however, of the first.

The work, commenced in 1857, has been energetically carried on since then without interruption, the mean daily progress having been about 5 feet. The tunnel route will furnish an uninterrupted railway communication between the north of France and the south of Italy, while the port of Brindisi, its southern terminus, is the place of departure and arrival of steamers to and from the East, through that other marvel of engineering perseverance, the Suez Canal.

An Old Invention.—"Before this period a Wm. Blakely, by a new application of Savery's engine, for which he obtained a patent, proposed to employ the expansive force of steam. This is the first plan for raising water by *strong* steam and by an easy transition to do anything else. The following sketch is taken from the author's small tract on the subject printed in French at the Hague in 1776."—*Treatise on Mechanics by Olinthus Gregory, London*, 1815.



The above is an early example of a shell-less, tubulous boiler, the type of numerous modern steam generators.

J. H. C.

Improvements in Safety-Lamps.—Several advances in this direction have lately appeared in our contemporaries which seem worthy of notice. Mr. W. Simpson has devised a self-extinguishing arrangement to accompany the lamp. It is designed to burn paraffine oil, which, as it affords a very brilliant light, is supposed partially to remove the incentive to remove the wire cage. Should the attempt be made to open it, it at once brings into action an automatic extinguisher, which consists of two small metal plates that fall upon the wick and its holder. The fall of the plates is caused by a spring which is released on unscrewing the cage from the lamp. A magnetic lock has likewise been designed by Mr. S. P. Bidder for use with the safety-lamp. This is so arranged that the bolt can only be withdrawn by the action of a powerful magnet, a strong electro-magnet is therefore permanently fixed in the lamp cabin.

As the collier could hardly carry with him without detection an instrument powerful enough to open it, the contrivance would seem to add considerable to his safety.

The Root Blower seems to be meeting with great success abroad as blast supply for cupola furnaces and also in many cases to take the place of the ordinary fan. They are used in a number of Bessemer works and some forty have been recently put up at different works near Glasgow, while in all, over three hundred are in operation throughout the country.

Proportion of Sliding Surfaces.—We see a reference in one of our contemporaries to the fact that if sliding surfaces are equal to each other they will wear true and straight, while if one is smaller than the other the smaller will wear convex and the latter concave. The reason of this is obvious on a little reflection. In the case of equal surfaces the wearing action will be greatest on the parts which are always in contact and will diminish to the outer extremities. As, however, the conditions are identical for each surface this will tend to make both concave, by which the bearing will be brought upon the ends until these are reduced to a normal condition. With unequal surfaces, however, the longer becoming concave through the greater wear of its middle portions, the shorter grinds away to fit it.

Railway Ties in South America are mostly obtained from California, as the hard wood ties cut on the Andes cannot be used without boring the spike holes with augers. The original cost of a tie cut at San Francisco being 40 cents, the additional freight and commission make it quite expensive, being one dollar at Callao.

A Pneumatic Despatch Tube.—An experiment designed to greatly facilitate the rapidity of delivering telegraphic messages is now being tested in the city of London. The continually increasing use made of the local telegraph, and the constantly increasing distance between the extremes of the business quarters, have rendered some other plan than that of delivery by messenger from the main office necessary. The messages as they arrive are sorted, and those intended for delivery a mile or more from the office are enclosed in a light cylinder, which is placed in a tube leading to a branch office in the neighborhood to which the messages are directed. The tube being properly closed, a strong current of air is blown into it behind the cylinder, and it is forced through to the branch office. Shunts are provided so that the carrier may be sent in any direc-

tion, the intermediate flaps being closed to allow it to pass. As to the time in which the delivery can be made, the *Mechanics' Magazine* states that a distance of 2058 yards between the offices was travelled over in about four minutes. It is said, thus far, to have been perfectly satisfactory. A plan of this kind might be very usefully instituted to facilitate the delivery of the mail of large cities. The letters, upon delivery at the main office, could be sorted, and sent rapidly to the several receiving offices, which might be of simple character, and judiciously increased. By this means the delivery of letters might perhaps be effected in a fraction of the time now required, thus contributing materially to public convenience and business interests.

The Effect of Cold on Iron and Steel.—It is somewhat surprising that a question of such paramount importance as the one heading this notice should still remain without the authoritative decision of that investigation of which it is worthy. Within the past few months several papers have appeared treating more or less elaborately of the subject, but far from setting the matter at rest, the experiments have led their authors to very contradictory results.

The general course of the experiments was that of selecting suitable pieces of cast and wrought iron and steel, and placing half of the number of each variety in a freezing mixture while the others were kept at the ordinary temperature. A cold and warm piece of each kind were now alternately subjected to a transverse strain and the amount of weight required in each case to break them was noted. The effects of a sudden blow were likewise noted by allowing a weight to fall upon the pieces from varying heights. The investigations of Sir W. Fairbairn and Dr. Joule declare that temperature has little or nothing to do with the strength of the metal. The breaking strain, indeed, was found to be slightly greater in the cold than in the warm specimens. These comprised both wrought and cast iron and steel. The results of Mr. Peter Spence obtained with cast iron bars even indicate that reduction in temperature increases the strength of the material. Mr. W. Brockbank, however, who has expermented with cast iron bars declares for his result, that cast iron suffers a considerable diminution in strength and elasticity when the temperature is reduced below the freezing point, a decision precisely opposite of that arrived at by his fellow-investigators, pursuing the same general method of inquiry.

The explanation of this incongruity we have little hesitation in

assigning to a constant and neglected source of error in the mode of conducting the research, which must, until proper weight has been assigned to it, render the announcement of any general conclusion hazardous and unreliable. This source of error resides in want, or rather the entire absence of attention bestowed on the chemical character of the materials employed. The very important influence exerted upon the quality of iron, and especially upon those very properties, the conditions of which are being discussed, by the presence, in greater or less proportion, of phosphorus and sulphur is too patent to be more than mentioned; and for aught that has been shown to the contrary, the brittleness and tenacity of each variety as the temperature diminishes may be either increased or diminished according to its chemical composition. This, indeed, in view of the evident care in which the investigations mentioned were conducted, as might have been anticipated from the character of their eminent authors, seems to be the most rational method of accounting for the contradictory nature of their conclusions.

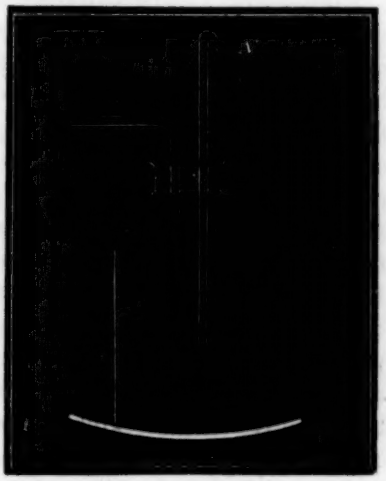
Until, therefore, investigations are conducted with irons of different quality, and an accurate analysis of each shall accompany the same, the question must still be considered an open one.

An ingenious application of the Spectroscope.—We learn from the *Quarterly Journal of Science* of a most ingenious use of the spectrum analysis, which will doubtless suggest the usefulness of extending its application to the elucidation of many inquiries, where it has heretofore not been appealed to. The case referred to is substantially as follows: The water used by the inhabitants of a crowded court, amongst whom several cases of typhoid fever had appeared, was drawn from a rather shallow well, and was highly charged with various unoxidized compounds of nitrogen. It was suspected that, from some defect, the contents of a public urinal obtained entrance to the well. The fact that the well-water contained seven times as much common salt as the normal water of the vicinity was some confirmation of the suspicion. Prof. Church obtained absolute proof by the following method. He introduced two grammes of a lithium salt into the urinal, and, two hours later, was enabled readily to detect with the spectroscope the presence of lithium in a litre of the well-water, which by previous examination had shown no trace of this substance.

Corrugated Flames are described by E. Villari in *Pogg. Ann.*, from an interesting experiment. Approach a tuning-fork vibrating

horizontally to an ordinary gas flame, so as almost to touch, and the volume of tone will be largely increased, showing that the flame takes part in the vibration, although it presents no marked change in appearance to the unaided eye. To make the vibrations visible, take a card disk, kept in uniform rotation by wheelwork, and provided with 16 slits each, 2 to 3 millimetres wide and 7·5 long, and place this from 8 to 20 inches from the gas flame. To prevent the currents of air produced by it from disturbing the flame, a glass plate or large card having a large horizontal slit is placed between the flame and disk. On looking at the flame through the descending horizontal slits, it is immediately broken up into alternate bright and dark bands, ruuning horizontally across. The position of the tuning-fork is of no particular consequence as long as it is near enough, and even the sounding case of an actively vibrating fork may be used. In this case the wavy flame can often be seen directly, without the aid of the rotating disk.

A New Experiment.—In the phenomenon of the spheroidal state, the globule will float when the vapor beneath it is able to support the pressure of the atmosphere plus the weight of the globule. If we remove the former factor, a much smaller vapor-tension will be required to produce the phenomenon, as may be proven by the following experiment, described by E. Budde,* in which, with the aid of the air-pump, a Leidenfrost globule is supported upon a metal plate whose temperature is below 100° C. A bell-shaped glass vessel, *g*, is firmly cemented to a copper plate, *a*. Through the stopper which closed the upper opening, pass two glass tubes, *l* and *m*. The first attaches by caouchouc tubing to the air-pump. The second reaches within the vessel nearly to the plate *a*, while above, it is closed and bent into an N form. The bent portion is filled with water. The plate is now placed upon the water-bath, which soon imparts to it a temperature of from 80° to 100° C. The air-pump is now put in operation; the water in *n* evolves air-bubbles and vapors (gentle heating will facilitate the



* *Pogg. Ann.*, CCXVIII, 158.

operation) which mainly accumulate in the upper end of the tube—and force a portion of the water through *m*. The water falls boiling, or very nearly so, upon the plate beneath, the temperature of which is, under the abnormal conditions, considerably above the boiling point of the water—and all the conditions necessary for the production of the spheroidal state are present. If the rarefaction is carried until the barometer indicates $10^{cm.}$ (about 4 inches) of mercury, and the water-bath is heated to about 90° C., the experiment will succeed without the slightest difficulty, and the spheroids obtained will evince an energetic movement.

The experiment is not a mere physical curiosity, but possesses an importance which our educated readers will doubtless have already appreciated, inasmuch as it is decisive in confirming the theory of the spheroidal state. It proves that the force which sustains the globule obeys the laws which govern the tension of vapors.

Vanadium.—From Prof. Roscoe's recent investigations upon Vanadium and its compounds, which comprise about all the literature extant upon the subject, we are able to condense the following concerning the preparation of the metal and its properties. It is obtained by reducing one of the chlorides (free from oxygen) in a stream of hydrogen, either with or without the aid of sodium. It is a matter of the greatest difficulty to obtain the metal entirely free from oxygen, since at red heat it absorbs this element with the greatest energy. The entrance of every trace of air or moisture during the reduction must therefore be most carefully avoided; but owing to the length of time required for an operation (40 to 80 hours, according to the quantity of chloride), and the trouble of freeing the chloride entirely from water and oxygen, the attempt to obtain the pure metal is attended with unusual difficulties. A platinum boat is placed within a tube of porcelain, and the reduction effected in this. A greyish-white powder with silvery lustre is the result. It is unchangeable in air or in water, even when heated to 100° C. It may be heated in hydrogen to redness without fusing or volatilizing; when the powder is thrown into a flame it burns with the production of brilliant sparks; when rapidly heated in oxygen it burns to vanadic acid, and heated slowly in the air, it begins to glow, and a sub-oxide is formed, which passes by a succession of steps into the acid. It is insoluble in hydrochloric acid, but is readily dissolved in sulphuric acid. Nitric acid attacks it vigorously. Its specific gravity is 5·5.

Anomalous Spectra.—Kundt has found that besides red aniline mentioned in the last number of this *Journal*, almost all bodies, which in a solid state show distinct superficial colors, different from, and generally complementary to, those by transmitted light, give in concentrated solution anomalous spectra. Among these are all kinds of aniline blue, all of aniline violet that have been examined, aniline green (Hofman's green), indigo dissolved in fuming sulphuric acid, indig-carmine, carthamine, murexide dissolved in potash, cyanine, permanganate of potash and carmine. In all these red light is more refracted than blue, and in those which are mainly green by reflected light, if enough of this color is transmitted to appear at all in the spectrum, green is always least refracted. Cyanine, aniline blue, aniline violet and indig-carmine give the colors in the order, green, blue, red; cyanine is the best for these purposes and under favorable conditions gives the spectrum, green, light blue, dark blue, a dark space, red and an indication of orange. To obtain these results very concentrated solutions are required; for dilute solutions give only the ordinary spectra. To make the prism put a drop of the solution upon a piece of mirror-glass and press against it a similar piece with a sharp edge, at an angle of about 25°. It is only immediately at the angle that any light can be made to pass through these highly colored solutions.

Galvanic Engines.—We noticed in a late number of the *Chemical News* a quotation from one of our American journals, in which Mr. Highton's curious misconceptions and unsound deductions are connected with the reported miraculous performances of a galvanic engine at Newark, N. J. We see that at last Mr. Highton's errors are being noted and pointed out in the pages of the *Chemical News*, and we feel well assured that the time is not far distant when the perpetual-motion machine at Newark will reveal the true origin of its force, but in the mean time it may not be uninteresting to notice a fact or two which has a bearing upon the latter.

On page 410 of our last volume will be found a conclusion reached by Prof. Mayer after careful experiment, that "in a combination of spirals or in a helix the inductive action of the wire on itself, or of adjoining spirals or turns upon each other, has no effect upon their power of magnetization."

This evidently bears directly upon the claim that, by introducing a sheet of tinfoil between the successive layers of insulated wire,

wound on an electro-magnet, the power of the same was largely increased. It might, however, be objected that in the experiments of Prof. Mayer, copper disks were introduced between successive spirals, and not cylinders of conducting material between successive layers.

We have therefore made the experiment in this form, using the form of apparatus described by Prof. M. for comparison of strength in the magnetized cores, and found that when tinfoil was introduced exactly in the manner described by those claiming advantage from its use, no improvement whatever could be observed. H. M.

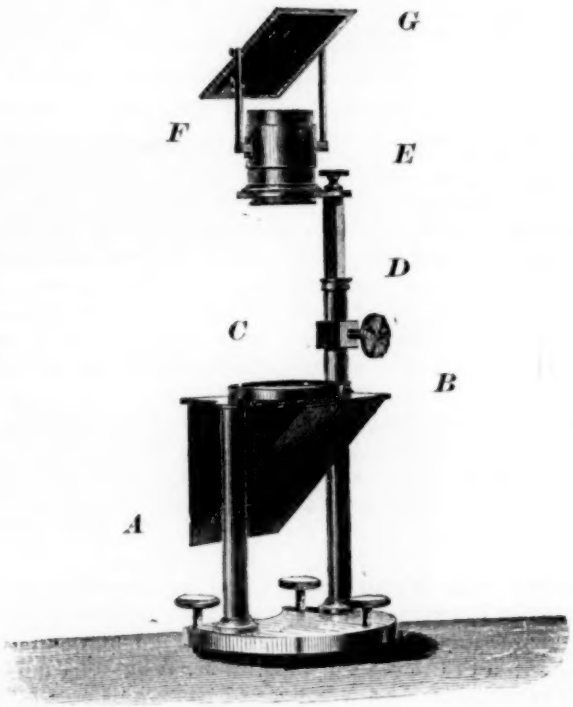
The Vertical Lantern.—At a late meeting of the Franklin Institute, Prof. Morton exhibited a new instrument which he had lately devised, and which, by the beauty and singularity of the effects it developed, elicited many expressions of approbation. The object aimed at was to produce on a vertical screen enlarged and brilliant images of objects which require to be maintained in a perfectly horizontal position, such, for example, as waves in a tank of water, cohesion, figures of oils, and other liquids, magnetic spectra and the like.

In a few introductory remarks the Professor observed that many efforts, attended with more or less success, had been made before with the same objects in view; thus Faraday and Tyndall had turned an electric lantern over on its back, so making the condensers horizontal, and the object being placed upon them, its image was either projected on the ceiling or reflected to the wall. The inconvenience of this plan was, however, very great, as would readily be perceived.

His attention was first drawn by Prof. Cooke, of Cambridge, to another plan which that gentleman had employed for several years. In this case the lantern stood in its usual position, and a mirror placed in front at an angle of 45° reflected the light upwards through the horizontal object and object-glass, beyond which a mirror, silvered on the outside by Focault's plan, reflected it to the screen.

The difficulty here, however, was that the object being removed to a considerable distance in front of the condensers, a very much discolored and unsatisfactory field of light was obtained on the screen. So that the many beautiful experiments with waves, &c., which the Professor had developed, lost somewhat of their effect. To meet this difficulty the speaker had therefore constructed the instrument as follows:

The lantern condenser in the first place was made of three lenses, the first two of such curve as to give, with the light at about two inches from the nearer one, a practically parallel beam, which was received upon a mirror, AB, at 45°, and after reflection from it fell upon the third lens placed horizontally at C, which concentrated it on the objective at E, from which it passed to the mirror FG, which in turn threw it on the screen. This mirror, moreover, was not silvered on the exterior surface but in the usual way on the back, though with pure silver, and yet no want of definition was to be



perceived in the image, owing no doubt to the fact that the faint reflection from the first surface was inappreciable in comparison with that from the metallic silver. In several articles published in the *Chemical News* and elsewhere, a square prism had been described as being used for the purpose, but a little thought, or still better, a moment's experiment would show that this means would not answer, because about one-third of the cone of rays entering the prism would be at too great an angle for total reflection, and would thus

leave one-third of the field dark. The instrument had been constructed by Messrs. Hawkins and Wale, to whose judgment and workmanship it did great credit. The apparatus was then put in operation, being illuminated with the lime light, and there was first shown a magnetic spectrum. Iron filings being evenly scattered over a plate of glass, a small steel magnet was placed beneath, and the glass lightly tapped with a pencil point, when the filings arranged themselves in the graceful inflections of the magnetic curves. A tank of water was then introduced, and by means of an ingenious contrivance devised by Messrs. Hawkins and Wale, series of waves were developed, and their reflections from the sides of the tank, interferences and other phenomena were beautifully exhibited. The apparatus for producing the waves consisted of a metallic box with a sheet rubber cover, provided with a long thin metal tube; this was so placed that the tube was about one-quarter of an inch above the point in the tank which it was desired to make the centre of the wave motion. On tapping the rubber diaphragm a momentary puff of air was driven from the tube, producing exactly the disturbance needed. An elliptical ring being placed in the tank, the properties of the curve with regard to reflections were very neatly exhibited, and, in fact, independent of their scientific interest, nothing could be more charming than the pearl gray waves crossing and interlocking and combining in complex patterns, which ran across the screen.

Cohesion figures produced by letting fall drops of ether, alcohol, carbolic acid, oils of cinnamon, coriander, cloves, etc., on the surface of water were then exhibited, and attention was directed to many other experiments, such as the electric decomposition of metallic solutions, sound figures and the like, for the exhibition of which this instrument was especially adapted.

Discovery of a Bone Cave.—In the limestone quarries of Port Kennedy, Pennsylvania, the workmen exposed what was once a cavern, at the junction of this rock with the new red sandstone. An examination of the same by Mr. C. M. Whately has resulted in securing the remains of no less than 47 species of post-tertiary animals, plants and insects. Amongst the first were found representatives of many of the gigantic forms of that time, including the mastodon, tapir, the large sloths, megalonyx and mylodon, a species of horse and several bears. Many of the bones and teeth were well preserved. The discovery is an unusually interesting one to the palæontologist as affording the first instance in our state of a bone cavern containing such extensive relics of the larger extinct quadrupeds. Mr. Whately has communicated to *Silliman's Journal* (April, 1871) a detailed account of his interesting discovery to which we refer those of our readers who desire further information on the subject.

Editorial Correspondence.

SUEZ CANAL.

THE following communication from Prof. J. E. Nourse, which arrived to late for incorporation with his interesting paper in our last number on the Suez Canal, will be found to contain the fullest confirmation of his assertions concerning the immensely growing importance of traffic through it, while it earnestly calls attention to the condition and possibilities of American enterprise in this direction.—EDS.

Dr. W. H. WAHL:

Dear Sir—Since sending the article on the Canal, I have been favored with the sight of an important and recent despatch from the U. S. Consul at Port Said, which I subjoin in the form of an almost literal copy. Yours, &c., J. E. NOURSE.

CONSULATE OF UNITED STATES, PORT SAID,
January 14, 1871.

HON. W. HUNTER, *2d Ass't Sec'y State:*

Sir—In my enclosure in a former dispatch, I had the honor to invite attention to the large increase of traffic through the Suez Canal—no fewer than *seventy-two* steamers having passed from sea to sea in the month of December, 1870, against *nine* only during the same month in 1869.

Of the 72 steamers, there were the following flags, viz:

British	39,	Registered Tonage			32·818
Turkish	12,	"	"		7·331
Australian	7,	"	"		6·141
Egyptian	6,	"	"		3·990
French	6,	"	"		7·870
Italian	1,	"	"		508
Dutch	1,	"	"		159

These ships are employed in the trade between the British, French, Italian and Dutch ports, with the coasts of Arabia and Persia, and with China, Japan and the Islands of the Pacific. There were 4 monitors from England, 2 for Bombay and two for Australia, to be stationed there.

As the result of my observations on the new resources developed by the opening of the Canal and the establishment of this port, I

beg leave to state that I find great encouragement for our American ship owners to establish a line of ships between our ports and India and China via the Canal. Port Said is now one of the most safe and accessible harbors in the Levant, with a perfectly straight entrance from the sea and *twenty-eight* feet of water in the channel.

Apart from the countries east of the Cape of Good Hope, a large amount of freight might be obtained for the United States, composed of gum and coffee from the Arabian coast, wool from the coast of Syria and the Euphrates, fruit from Smyrna, and tallow and lead from Odessa; with all of which places Port Said is in constant communication by steam; not to mention the miscellaneous contributions that might be brought by the regular line of steamers from Trieste, Greece and Constantinople.

If something is not soon done by our merchants, it is certain that the whole trade between the United States and the Levant, as well as of India and China, will pass under the British flag and be conducted through British ports by British merchants.

As a striking instance of the effect of the neglect of Congress to take some steps for the protection, or rather revival of our shipping interest, a few months since a large steamer, built in Glasgow upon the plan of our river steamers, passed through the Canal, bound for China, where she is to be employed in the river trade. During some years past many of the steamers of this class have been ordered from America, but this is the first one built abroad for foreign order; and we are in imminent danger of losing the advantage which has hitherto been a *quasi* monopoly of our merchants, derived from the construction of a class of vessels in every respect so peculiarly *American*.

(Signed) C. R. PAGE, *U. S. Consul.*

Cornish Engines.—*Errata.*—The following errors have inadvertently crept into the several papers on the above subject, by Mr. West. Our readers may correct the same by the references given below.

Last paragraph, page 24, January, 1870, instead of "imperfectly *constructed* experiments, read imperfectly *conducted* experiments."

First full paragraph, page 176, March, 1871, instead of "the friction is increased *inversely*, read "the friction is increased *immensely*."

Last paragraph, page 179, March, 1871, instead of "the Fowey Consols engine Rowan's," read "The Fowey Consols engine *and* Rowan's."

Civil and Mechanical Engineering.

AN EXAMINATION OF SOME EXPERIMENTAL FACTS BEARING UPON THE PROPER RATIO OF THE LENGTH AND BREADTH OF STEAMSHIPS.

By Alban C. Stimers, Naval Engineer.

(Continued from page 266.)

To solve this, let us suppose five ships built of iron of the most approved construction, having the proportions and co-efficients of performance of the five classes just examined; let each have a cargo carrying capacity of 3,000 tons, and a speed which will achieve the distance of 3,000 miles in 10 days; and let them be of equal stability and strength.

It will first be necessary to determine the proportionate weights of hull for equal displacement, when the proportions of the different classes are employed. The best ships are now built on the theory that they are great hollow beams, having at least one deck of iron to form the *upper flanch*, while the bottom corresponds with the *lower flanch* and the sides the *web*. For convenience of comparison, let us suppose the vessels to have the simple form of a double wedge as in the annexed figure.

The proportionate lengths and breadths being already fixed upon, it is necessary to make the depth in each case such that the vessels will have equal stability.

$$\text{Let } \text{L} \times \text{B} \times \text{D} = c, \quad . \quad . \quad . \quad . \quad . \quad (1.)$$

$$\frac{\text{L} \times \text{B}^3}{\text{D}} = s, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2.)$$

$$\text{and } \frac{\text{B}}{\text{D}} = h, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3.)$$

The contents of the vessel represented by c (formula 1) is a uniform quantity in all the classes by the postulate, and where c is maintained uniform, s (formula 2) and h (formula 3) will be uniform quantities with vessels having equal stability.

Mr. Scott Russell in his great work on *The Modern System of Naval Architecture* describes an iron steamer, the *Annette* (pp. 375 and 618) which he commends as an example illustrating the advantages of the longitudinal system.

In this vessel it appears that the iron devoted to the longitudinal strength of the hull was 18·4 per centum of the displacement, and that devoted to transverse strengthening 3 per centum.

The proportions were such that—

$$\text{If } B = 1,$$
$$\text{then } L = 6{\cdot}33,$$
$$\text{and } D = {\cdot}6.$$

Employing these proportions and the corresponding weight of hull as an example, we easily arrive at the weights of hulls having equality of strength and built upon the proportions under examination.

Let the above numbers stand for dimensions; the length of a vessel having equal capacity but a different ratio of length to breadth will be found by the following formula—

$$L = \sqrt{6{\cdot}33\ R^2}, \quad . \quad . \quad . \quad . \quad . \quad (4.)$$

The *extent* of the skin, and all the other longitudinal strengthening will, of course, vary directly with the surface; and its *thickness* to maintain equality of strength, directly with the ratio of the length and depth.

Continuing to employ the foregoing numbers for dimensions, we find the content of the figure to be 1·9, and its surface 14·0277. The following table exhibits clearly the comparative surfaces and weights of the various classes, and the resulting per centum of displacement required by each class for longitudinal strength.

a. Class.	b. Ratios of L to B.	c. L.	d. B.	e. D.	f. Surface.	g. Comparative Surface.	h. Comparative L. to D.	k. Comparative weights of Long. Iron.	m. Per ct. of Displacement of Long. Iron.
Example	6·333	6·333	1·000	0·600	14·0277	1·00000	1·00000	1·00000	18·40
A	3·37	4·159	1·234	0·740	11·5550	0·82373	0·53240	0·43860	8·05
B	4·03	4·678	1·164	0·698	12·1746	0·86790	0·63470	0·55085	10·14
C	5 00	5.410	1·082	0·649	12·9948	0·92637	0·78947	0·73134	13·46
D	5·84	6.000	1·027	0·617	13·6737	0·97476	0·92210	0·89883	16·54
E	6·86	6·680	·974	0·584	14·3908	1·02588	1·08470	1·11277	20·47

In the above table the quantities in columns *c*, *d* and *e* are such that, while they maintain equal capacity with the example, each preserves its own pecular ratio of length to breadth. The quantities in column *f* give the corresponding extent of surface of the figure shown in the cut; those in column *k* are obtained by multiplying corresponding quantities in columns *g* and *h*, column *h* representing the comparative thickness of the longitudinal iron necessary to maintain equality of strength in hollow beams having the proportions given in the table.

The transverse stiffening would be practically uniform for the different classes, and is, as we have seen, 3 per centum of the displacement in the example.

The *equipments*, which, in this case, would include all wooden decks, all joiner work, masts, rigging, sails, boats, anchors, &c., &c., may be taken uniformly at 15 per centum of the displacement.

The total weights of vessel, exclusive of machinery, coals and cargo would therefore be as follows:

Class A	26·05	per centum	of	the	displacement.
" B	28·14	"	"	"	"
" C	31·46	"	"	"	"
" D	34.54	"	"	"	"
" E	38·47	"	"	"	"

With the foregoing, in connection with the co-efficients of performance achieved by each class, we may arrive at the actual displacements, powers and weights of steam machinery and weights of coals necessary in each case to carry 3,000 tons of cargo a distance of 3,000 miles in 10 days. Whence the first cost of the ships and machinery may be estimated.

This is shown in the following table, where the horses-power of the machinery is determined by the co-efficient of performance belonging to each case. The weight of the machinery is taken at one ton for every 10 horses power, and the coals at one ton per day for every 30 horses power. The displacements given supposes half the coals burned out. The cost of the hull and equipments is taken at $250 per ton weight. That of the steam machinery at $40 per indicated horse-power. These latter quantities are, of course, variable with time and locality as well as with the character of the detail design, but they are sufficiently near the average for purposes of correct comparison.

Class.	Co efficient of Performance.	Weight of Cargo.	Weight of Hull and Equipments.	Wht of Steam Machinery.	Wh't of Coals.	Mean Displacement.	Horses Power.	Cost of Hull and Equipments.	Cost of Steam Machinery.	Total Cost.
		Tons.	Tons.	Tons.	Tons.	Tons.		$	$	$
A	134·9	3,000	1,490	463	1,544	5,725	4,633	372,500	185,320	557,820
B	155·1	3,000	1,592	400	1,332	5,658	3,998	398,000	159,920	557,920
C	175·7	3,000	1,815	358	1,192	5,769	3,576	453,750	143,040	596,790
D	177·8	3,000	2,097	366	1,218	6,072	3,655	524,250	146,200	670,450
E	198·9	3,000	2,430	336	1,120	6,331	3,360	607,500	134,400	741,900

The annual expense of the capital invested in ships is as follows:

Wear and tear	10	per cent.
Depreciation	5	"
Insurance	10	"
Interest	7	"
Total	32	"

The current running expenses will be equal for the different classes under consideration, with the exception of the coals, the variation in which is shown in the above table. In the following table it is assumed that each vessel will make eight round trips per annum, and that the cost of the coal in the bunkers is $6 per ton. Adding these two variable quantities together, we have the comparative annual expense of running steamers of equal gross earn-earning capacity.

Class.	A.	B.	C.	D.	E.
	$	$	$	$	$
Annual expense of capital	178,502	178,534	190,973	214,544	237,408
Annual expense of coal	148,224	127,872	114,432	116,928	107,520
Total of the variable expenses	326,726	306,406	305,405	331,472	344,928

To complete the illustration, let us suppose that the gross earnings are $360,000 per annum in excess of the uniform annual expenses which have not been taken into account in the foregoing. The *net* earnings will then be as follows:

Class A	$33,274
" B	53,594
" C	54,595
" D	28,528
" E	15,072

And the per centa which these sums bear to the first cost of the ships in the respective classes are as follows:

Class A.	5·96
" B	9·61
" C	9·15
" D	4·26
" E	2·03

From this it appears that, with the average performance of the entire British screw-steam navy, previous to 1865, for a standard, the proportion of four lengths to one breadth will earn better dividends upon the capital invested than any higher ratio. The excess over that of 5 to 1 is 0·46 per cent., in other words they may be said to be equal. The excess over 5·84 or say 6 to 1 is 5·35 per cent, and over that of 6·86 or say 7 to 1, it is 7·58 per centum.

As it may be fairly assumed that the vessels exhibiting the poorest performance have an inferior application of steam power, or are of inferior model, independent of the proportion of length to breadth, I have obtained the means of half the vessels in each class which exhibit the best performance. Those marked with an asterisk in list are the ones chosen. The results are given in the following table.

Class	Number of Vessels.	Ratios of Length to Breadth.	Speed in Knots per hour.	$\frac{V^3 \times D^{\frac{2}{3}}}{H.P.} =$
A	6	3·38 to 1	10·340	159·2
B	32	4·15 to 1	10·671	181·1
C	39	4·71 to 1	10·016	197·9
D	34	5·71 to 1	10·170	198·1
E	13	6·98 to 1	11·217	252·4

(To be continued.)

WOOD-WORKING MACHINERY.

A treatise on its construction and application, with a history of its origin and progress. By J. Richards, M. E.

(Continued from page 237.)

THERE is no subject more interesting to the engineer than the early history of machines and structures with which he comes in contact. To trace the gradual developement of art, appreciating the anxiety, risk, and labor that has been expended upon it, possesses a fascination that might almost be defined as morbid curiosity. A judgment, however, which may be very harsh, when we consider the time and money that is expended in the search after antiquities without the hope of a result that will contribute anything to the general good.

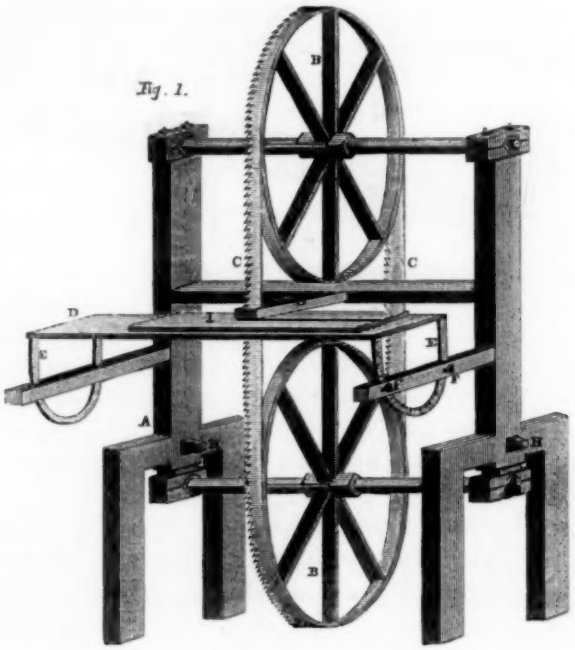
Contrasted with searches after the remains of the "mound builders," or the "north-west passage," we assume that the early history and facts connected with the mechanic arts forms a much more useful, and, to the mechanic at least, a more interesting field. The want of connection between operative mechanics and literature has, however, left but a meagre history of the useful arts compared to what we know of war, political contention and human passions generally.

We should venerate our patent system and cherish it, if for nothing else, then for what it hands down in the way of history of mechanic arts. Without these records we would be barren indeed as to the origin and progress of what is most vital and important to civilization, and it is with astonishment that we see a member of the British Parliament attack the patent system as useless and mischievious. We hope, as the greatest good that the honorable member may ever accomplish, that he will be able in his life to confer on his constituents a tithe of the good that has arisen from the laws he so violently assails. In the United States it is to be regretted that we are practicably cut-off from such records as exist of machines for working wood and iron. We have the British patents to be sure in our own language and on public file in various parts of the country, and no doubt they contain the most that is important or interesting in reference to the early history of machines. Yet, it is to be inferred that in wood-cutting machines and engineering tools, the continent can claim the greatest antiquity. Germany,

France and Spain have each contributed no doubt their share, and in advance of the English, but they lacked both the public spirit and that peculiarity which has been called abstraction in the Anglo-Saxon people; a tendency to abstract utility, and deduce profit and advantage from what would be viewed only as curious or beautiful by others.

The band saw was alluded to in a former article of this series as an invention whose history seemed wrapped in obscurity. We now (although somewhat out of place) desire to qualify that statement and give the result of a more diligent search, which has been rewarded with the discovery of what must for the present be accepted as the first practical band-sawing machine, an instrument that contained about all the parts and was capable of all the functions found in the modern machine.

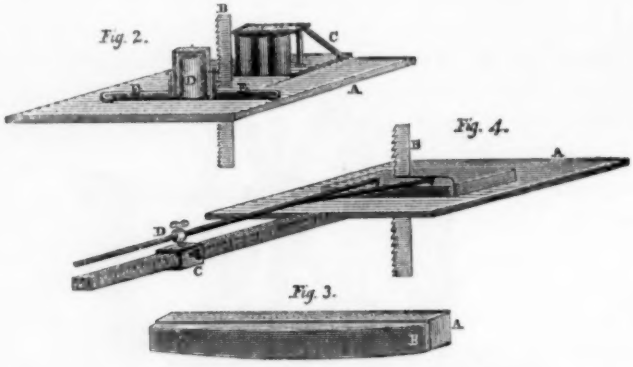
Fig. 1.



Mr. William Newbury, of St. John Street, County of Middlesex, London, England, in 1808, invented a band-sawing machine, of which an illustration is here produced. The drawing looks antiquated as to the plans of construction, but when we consider the

time and surrounding conditions of the art it is a surprisingly perfect machine. Letters patent from the crown were granted to William Newbury, Gentleman, for an invention of certain machinery for the purpose of sawing wood, splitting or paring skins and various other useful purposes, dated Jan. 30th, 1808.

We have in this machine the pivotal table with the axis of motion when the blade intersects the plane of the top, there is also shown feeding rollers at Fig. 2, similar to those afterwards patented to Woodworth for planing machines. There is also a graduated radius attachment shown at Fig. 3 for sawing true sweeps, in fact, aside from the trouble of placing and removing the saw the machine is quite as good as some machines that have appeared in the last five years.

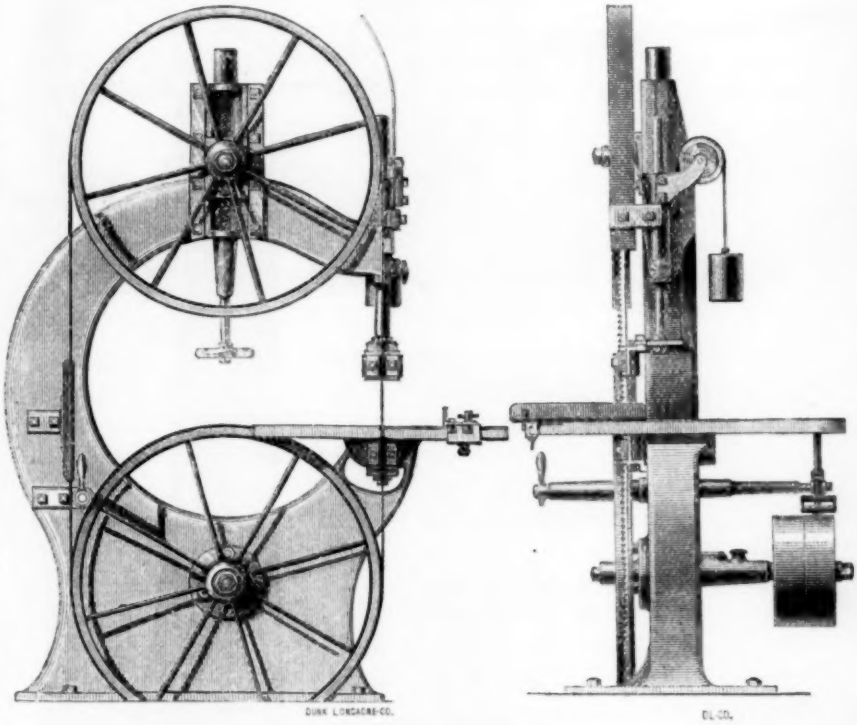


This machine is alluded to in "Holtzapffel's Mechanical Manipulation" as a very curious one, which is a sufficient warrant as to its non-use at that time (1846).

As the subject of band saws has been to this extent resumed, we avail ourselves of the opportunity of presenting an illustration of an improved band saw from the designs of Richards, Kelly & Co., of this city, Figs. 5 & 6. The general style of framing and guides is the same as their machines illustrated in former articles. The frame is, however, of rectangular curved section, without ribs and perfectly plain on its exterior. The main new feature, aside from the minor changes in mechanism, is the wheels, which are of *wrought iron* covered with wood, and then with a layer of heavy harness leather. This form of wheel combines great strength with elasticity and a neat appearance. The elasticity in the wheel acts directly upon the

blade without the intervention of other mechanism and lessens the danger of breaking. The wood is fastened to the iron rim by screws and the leather is glued to the wood so that the joints are all reliable. The wheels of the machine illustrated are of 40 inches diameter, the iron rim $\frac{1}{4} \times 2$ inches, the wood $\frac{7}{8} \times 2\frac{1}{4}$ inches, the spokes 8 in number of round iron $\frac{3}{4}$-inch diameter.

Figs 5 and 6.

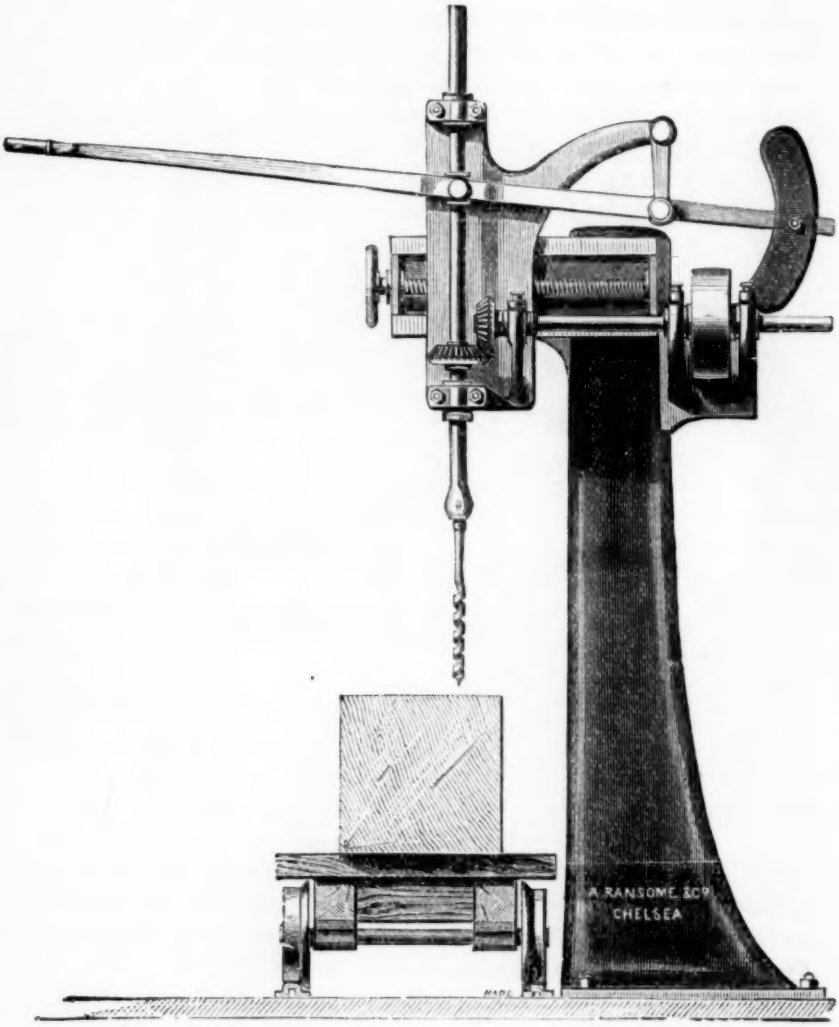


The wrought iron wheel will be adopted hereafter by this firm on their larger machines and can be built of any diameter required up to 12 feet.

We present at Fig. 7 an illustration showing a side elevation of a boring machine by Allen Ransome & Co., of London, England. The machine is intended for boring in wood framing of all kinds, The spindle has a lateral traverse of 15 inches, and a vertical movement of 16 inches.

The weight is, with the carriage, about two tons.

Boring machines for wood correspond to drilling machines for metal, except as to the greater speed of the spindles, the adjustments and movements are the same. The modifications met with are as



various as the purposes to which they are applied and no standard form of construction has been adopted by the makers.

We will notice, however, a machine built in Indiana some four

or five years since wherein the traverse movement of the spindle was performed by power; that is, the lateral adjustment was performed by the machine itself through the means of friction clutches. This involved quite a complication of mechanism beneath the spindle without any equal object in adjusting the bit; an operation that requires but little power and has in the end to be governed by hand adjustment; in short, it is as easy to adjust the bit and spindle as it is to adjust the friction clutches. A compound vertical machine with two spindles having 12 inches traverse and 16 inches vertical movement of the spindles, was arranged, and is now building by Richards, Kelly & Co. for J. Dripps, C. E., Superintendent of Motive Power, Pennsylvania R. R. Co. This machine is framed in iron, weighing 1500 lbs. with traversing table.

(To be continued.)

ENGINEERS AND MACHINISTS.

By J. Richards, M. E.

The manufacture of machinery can, and perhaps should, be divided into three branches: engineering, machine fitting, and the commercial department. In this country a person or a firm, in order to found a successful business, must, in some degree, compass all of these things; they must generate designs, carry them out in the construction of the machines, and then negotiate their sale. To theorize on the subject without considering the history of the mechanic arts, there would seem to be a legitimate division of these separate branches, and no doubt such a conclusion would be correct if it were practicable to divide them with the present degree of knowledge possessed of the forms of construction and means of fitting. And it is safe to assume that the necessity of this combination is found in the imperfections of the art. Designs have to be qualified by experiment, and sales negotiated that are contingent upon successful performance, and in order to meet these conditions the whole must co-operate together.

That the principle is the same in a general way that leads to a division of labor in the shops, cannot be denied, the object being to systematize and produce cheaper. Any manufacturer that is not trammeled and worried by the care and risk of making designs and plans, and can give his entire attention to shop manipulation,

can make machines better and cheaper than if he attends to both. Again, relieve him of all commercial care and responsibility except the purchase of material and his pay roll, and the result must be that no mongrel business could be done to compete.

In England we have an indisputable evidence of this in the manufacture of staple articles, at Birmingham and elsewhere. The manufacturers go to London and contract for a season's production with some commercial house, to whom all their goods are sent. They then go home to give their attention solely to the details of their shops. The plans and designs have been fixed by custom and experience and the goods are sold by others. The consequence is that the cost of production has decreased until they can defy competition.

The great engineering firms of our own and other countries, it is true, have been founded and conducted on a different principle, and their example offers a strong argument for its continuance; but at the same time there are faults attending the most successful that must not be overlooked, one of which is that such shops are generally the product of a one-man power—some one endowed with an extraordinary ability and a versatility of talent that enables them to plan, build, and sell. This focal one-man power is to be found in nearly every successful engineering firm in existence, and the result is that when this power fails and is not supplanted by one similar and equal, there is soon a want for an epitaph. In fact, the ordinary ranks of mankind furnish but few men who can master and execute the details of a successful engineering business as now conducted.

There is against the system a powerful argument found in the fact that efficiency can only be attained by strict attention to one thing; and while we have a few first-class shops that do attain it in all departments, we have for each one such a score that make a miserable failure. Look over our country and no shop will be found however small, or no matter how much risk is being run in the use of a limited capital, but that is trying to produce something new and startling, some new modification of machines, or novel experiment that belongs to the engineer and not the machinist. It is even common for persons to advertise as engineers and machinists who have not the least capacity, education, nor means to generate designs nor to calculate plans; the result is generally failure—the inevitable failure to succeed in engineering, and the consequent fail-

ure of the machine shop for want of means squandered in experiment.

What is true in this respect with regard to engineering is equally true in reference to the commercial department of the machine business. As our shops are now organized, a machinist, to start business, must have all the adjuncts of a counting-room—a complication of accounts, a correspondence all over the country—he must advertise, travel—in short, expend on a business, no matter how small, the same amount that would be needed if he were doing ten times the business. This is the result of our conglomerate system of machine manufacture. And while it must be accepted as a necessity growing out of the unfortunate state of the art, it can do no harm to understand it and talk about. And while circumstance must perforce for a time maintain this state of affairs, our highest good and greatest success must ultimately grow out of a different system, in which the engineer is responsible for designs, the machinist for his work, and the commercial man for the contracts.

BELTING FACTS AND FIGURES.

By J. H. Cooper.

(Continued from page 271.)

A Large Leather Belt.

"At the New Jersey Zinc Co.'s works at Newark, N. J., is a quadruple leather belt of unusually large dimensions. It is 102 feet long, 4 feet wide and weighs 2200 lbs. The outside layer consists of two widths, the second and fourth layers of three widths, and the third layer of four widths; all the layers being rivetted and glued together, and the end joints of the pieces forming the several layers are lapped to give the greatest tensional strength to the whole.

"It runs on an engine band wheel 24 feet diameter, with straight face 4 feet wide of smooth turned iron and over a driven pulley on the line shaft of 7 feet diameter having similar face, the centre of which lies 5 feet above the engine shaft.

"It has been in use three years, is doing well and giving no trouble, even when doing its heaviest work.

"The engine has a cylinder of 28 inches diameter and 5 feet stroke, makes 35 revolutions per minute under 70 lbs. of steam and 14 lbs. of vacuum; estimated capacity of belt 250 horse-power, velocity 3080·7 feet per minute, and 49·3 square feet of belt traveling per minute per horse-power."—*J. Hartman.*

"*Band Links.*—Where tension alone, and not thrust, is to act along a link, it may be flexible, and may consist either of a single band or of an endless band passing round a pair of pulleys which turn round axes traversing and moving with the connected points. For example, in Fig. 1, A is the axis of a rotating shaft. B that of a crank pin. C, the other connected point, and B C the line of connection; and the connection is effected by means of an endless band passing around a pulley which is centered upon C, and round the crank-pin itself which acts as another pulley. The pulleys are of course secondary pieces, and the motion of each of them belongs to the subject of aggregate combinations, being compounded of the motion which they have along with the line of connection, B C, and of their respective rotations relatively to that line as their line of centers; but the motion of the points B and C is the same as if B C were a rigid link, provided that forces act which keep the band always in a state of tension.

"This combination is used in order to lessen the friction, as compared with that which takes place between a rigid link and a pair of pins; and the band employed is often of leather, because of its flexibility."—*Rankine's Mill Work*, p. 213.

"In Fig. 2 we give a substitute for Fig. 1, in which an excentric B takes the place of the crank, allowing a straight shaft to be used. When the excentricity of B equals the radius of the crank, the result is the same, but experiment has proven, in the case of the excentric used in the treadle arrangement of the latter, that the motion lacks freedom, the treadle moving heavily."

"*Cement.*—A cement for joining pieces of leather, one which repeated tests have shown to be very efficient, may be made by dis-

solving in a mixture of ten parts of bi-sulphide of carbon and one part of oil of turpentine, enough gutta-percha to thicken the composition. The leather must be freed from grease by placing on it a cloth and pressing the latter with a hot iron. It is important that the pieces cemented be pressed together until the cement is dry."

"*Cement for Fastening Leather to Iron or Glass.*—To one quart of glue, after it is dissolved in good cider vinegar, add one ounce of Venice turpentine, let it cook about half a day, when it is fit for use."—O. L. C., of N. H., in *Scientific American*, Feb. 11, 1871.

"*Cement for Leather Belting.*—"Of common glue and American isinglass, take equal parts; put them in a boiler and add water sufficient to just cover the whole. Let them soak ten hours, then bring the mixture to a boiling heat and add pure tannin until the whole becomes ropey or appears like the white of eggs. Apply it warm. Buff the grain off the leather where it is to be cemented; rub the joint surfaces solidly together, let it dry a few hours and it is ready for use. If properly put together it will not need riveting, as the cement is nearly of the same nature as the leather itself."—J. S. of Minn., in *Sci. American*, Feb., 1871.

Cement for fastening Chamois and other Leather to Iron and Steel.—Dr. Carl W. Heinischen, of Dresden, gives the following: "Spread over the metal a thin, hot solution of good glue; soak the leather in a warm solution of gall-nuts before placing on the metal, and leave to dry under an even pressure. If fastened in this manner it is impossible to separate the leather from the metal without tearing it."—G. E. M., of Texas, in *Sci. American*, Feb., 1871.

"*Adhesive for Rubber Belts.*—Coat the driving side with boiled linseed oil or cold tallow, which may be done while the belt is running and then sprinkle the surface evenly over with fine chalk. This will not injure the rubber, as the belt does not absorb the tallow."—C. E. G., of Ct., in *Sci. American*, Dec., 1870,

A good adhesive for leather belts is printer's ink. I have the case of a six inch belt running dry and smooth and slipping, which latter was entirely prevented for a year by one application of the above.

(To be continued.)

IRON MANUFACTURES IN GREAT BRITAIN.

THIRD PAPER.

By R. H. THURSTON,

First Asst. Eng., A. A. Prof. Nat. Philos., U. S. N. A.; Member of the Institute.

(Continued from page 259.)

THE next most interesting district to the American engineer is that from which we receive the large quantities of Scotch iron that are imported into our market.

Scotch practice is in marked contrast with that just described.

The furnaces are smaller than those of Yorkshire, seldom rising above 60 feet in height, as the materials charged do not seem able to bear great crushing weights. Even at 60 feet, trouble is found to arise from the coke falling down into the hearth unconsumed.

The number of furnaces reported in blast, at the time of our investigation, was 127, with a production of about one and a quarter millions of tons annually.

The production of the larger furnaces even seldom exceeds 200 tons per week.

As raw coal is used for fuel, the furnace gases consist largely of hydro-carbons, and are allowed to pass off freely from the open tops of the furnaces. No means of utilizing them are usually adopted, as attempts to take off the gases have generally occasioned serious irregularity in the action of the furnaces.

Table 1 contains an analysis of the remarkable "Scotch black-band," which is the principal ore of this district. It contains, usually, over 60 per cent. of metallic iron after calcining.

The roasting is often effected without expense for fuel, the carbon contained in the ore being sufficient for the purpose, and, in exceptional cases, amounting to 25 per cent. of its weight; the per centage usually ranges from 4 to 10. The calcined ore is charged into the furnace with from 20 to 30 per cent. of limestone, making about two tons, and sometimes less, of these materials per ton of iron made. The proportion of fuel used is, however, extravagant, averaging probably between 45 and 50 hundred weight per ton of iron, and to this is to be added the amount of "slack" required for heating the blast and making steam.

The countrymen of Neilson either do not appreciate the full value of his invention, or else are unable to avail themselves of it, and it seems quite surprising to find here a temperature of blast rarely exceeding 700°. Its pressure is, upon the average furnace, 3 pounds per square inch. The heating stoves are usually fitted with the "pistol pipe." The furnaces are usually in close proximity to both ore and coal, which are frequently drawn from the same shaft. The consequent cheapness of materials may have some influence in producing the great difference between the Scotch and the Cleveland practice.

A change for the better is said to be now noticeable, and it will, undoubtedly, be hastened by the increasing expense of Scotch ores and fuel and the rising competition of other districts.

The product of Scotch furnaces is usually of the well known dark foundry grades, and the phosphorous which it contains probably gives it its fluidity and easy fusibility. The lighter grades are made into fair wrought iron by careful puddling, and furnish a large proportion of the iron worked by the great shipbuilding establishments of the Clyde.

Staffordshire is at present the largest iron making district of Great Britain, but there is little to be noted here, the methods adopted being neither as economical as in Cleveland nor as wasteful as in Scotland, and similar remarks will apply to the iron producing portion of Wales. The latter district has the best coals for metallurgical purposes to be found in the country, and the manufacture is very largely developed both of pig metal and refined. There are about 120 furnaces in blast in South Wales, and large quantities of cast iron are worked into nails, bars and plates, and a considerable amount of steel is made by the Bessemer process. We give analyses in Table 1 of Staffordshire and Welsh ores.

The immense and extremely rapid growth of the manufacture of steel by the pneumatic process, in England, has caused a correspondingly urgent demand for ores of exceptional purity. It is well known by every engineer that this process cannot be successfully worked where the pig metal is not rich in carbon and free from sulphur and phosphorus. A minute quantity of sulphur may be present in the pig metal, as manganese acts, to a certain extent, as its antidote, but the presence of a fraction of one per cent. of phosphorus is fatal. As English ores are almost invariably contaminated to a considerable extent with these elements, the mines and

furnaces of Cumberland—almost the only locality where an ore can be obtained of a quality that may be used in this process—are rapidly increasing their production, while prices are rising so steadily and rapidly as already to cause some uneasiness to be felt by consumers.

The Cumberland and Lancashire, or "West Coast district," is situated at the north-west corner of England, and the largest manufacturing town is Barrow, a few years ago a mere hamlet, but now a city of 25,000 people. We give an analysis of the ore in Table 1. It is a rich, pure, red hematite, containing barely a trace of either sulphur or phosphorus, and is found in irregular masses in the limestone; its principal impurity is silica.

The fuel is generally Durham coke, with some admixture of native, which, however, contains too much sulphur and phosphorus. The furnaces are of medium size, with blast heated to 800° Fahr., and at a pressure of about 4 pounds per square inch.

The product is about 400 tons per week as an average for the more recent furnaces.

The manufacturers of Cumberland are now receiving above £4 per ton for their No. 1 pig metal—over fifty per cent. more than is paid for other irons—and are still unable to supply the market.

British manufacturers still use the old crucible process in making the finer grades of steel, and the amount produced is by no means small in the aggregate, but, for the "mild steel" which is required for rails, boiler and ship plates, shafts, and many other purposes for which wrought iron was formerly used, the pneumatic process is principally employed.

The largest manufacturing establishment working this process is the Barrow Iron and Steel Works.

Here the pig iron is melted in eight-ton charges in *cupola* furnaces, with coke as fuel, the pressure of blast being about one pound per square inch. For reheating the ingots, the Siemens gas furnace is used, and is found vastly more efficient, in every way, than the ordinary furnace. Uniformity of character in the pig iron is secured by breaking the pigs and distributing the pieces among the large number of heaps into which the stock is separated.

The spiegeleisen is principally imported from Germany, and the war, just terminated, has seriously interfered with steel making throughout Great Britain, although, occasionally, as at the Dowlais Works in South Wales, unusual foresight had, at its outbreak, secured a large stock—sufficient for several months.

Some difficulty is found in making, with ordinary spiegeleisen, a steel rich in manganese and at the same time containing a sufficiently small per centage of carbon, and some attempts have been made to manufacture an alloy of iron and manganese, with a small quantity of carbon, for the especial purpose of making a good quality of metal containing less than one-half per cent. of carbon. Such a metal would be largely used where sudden strains are to be resisted, as in armor plate and ordnance. The manufacture of this "ferro-manganese" has not, however, become a commercial success, although good samples have been made.

The greater portion of steel made by the pneumatic process in England is, as in the United States, rolled into rails. Barrow rails are well known in this country, thousands of tons having been imported for our principal railroads.

The Dowlais Works are also large manufacturers of Bessemer steel. This immense establishment was built up by the well directed intelligence of one man, Sir John Guest. About 10,000 people are now employed in its works and mines.

The Dowlais Works produce annually 30,000 tons of steel rails, from ore mixtures consisting largely of Cumberland hematite, and probably four times as great a quantity of iron rails from native ores. A considerable quantity of Spanish-Bilboa ore is imported, at a cost of about 16 or 18 shillings per ton, and being of quite good quality, it mixes well with more expensive ores, in steel making, and with native ores for iron making.

We noticed at Dowlais, as well as at other rail mills, that the rolls were arranged to reverse, the older by clutches, the more recent by the Ramsbottom reversing engine, which seemed always to give perfect satisfaction to both workmen and managers.

We found Bessemer plant and steel rolling mills at the well known Sheffield establishments of John Brown & Co. and Cammell & Co., both of which firms have a reputation in the United States as makers of steel rails. These establishments have immense rolls for the manufacture of armor plate, which they turn out of a thickness of 14 and 15 inches. The rolls are only remarkable, however, for their great size and strength; there is no novelty in their design.

The "Siemens-Martin" process of steel making is in successful operation in Great Britain, as in the United States, and we had the

pleasure of witnessing it at the "Siemens' Works," at Landore, South Wales.

The Bessemer process is only adapted to working, advantageously, the purest of cast iron, and that only when containing a large amount of graphitic carbon and of silicon; the character of the charge cannot be well ascertained until actually poured from the converter into the ingot mould, when it is too late to remedy any defect; scrap metal and white irons cannot be used in decarbonizing. The great advantage of the process is simply the rapidity of conversion and its economy when competing with the old method of steel making.

In the Siemens-Martin process the pig metal is melted on the hearth, and, under the intense heat of the Siemens gas furnace, it is kept fluid, even after the addition of wrought iron—either in form of scrap or puddle balls, usually—has decarbonized it.* Spiegeleisen is then added, as in the Bessemer process, and the metal is tested by withdrawing a spoonful, and more pig iron or scrap or spiegeleisen, as either may be required, is added until the desired quality is obtained.

In this process a white cast iron may be used to better advantage than grey, scrap metal and other cheap decarbonizing material may be used, and the charge need not be tapped off until it is of precisely the quality demanded, as the molten metal may lie as long as may be convenient under the neutral gas flame without loss of iron or change of character.

The process was in regular working at Landore, and the product was of excellent quality and admirable in its uniformity of character.

The commercial success of the process will depend largely upon the relative cost of foundry and forge irons and upon the price of scrap, but from statements of cost furnished at Landore, it would seem a much more profitable process of steel making, at present, than the pneumatic method. The metal being worked on the hearth of the reverberatory furnace, a judicious use of good fettling material, by taking off sulphur and phosphorus, enables a less pure iron to be worked, also, than can be used in making Bessemer pig.

*The inventors and those who are working this process have a theory that the decarbonization is, at least partly, due to a "dissociation" of the carbon from the metal at the intensely high temperature at which it is kept in the "Siemens furnace, and the remarkably small proportion of malleable iron required seemed to indicate that the process is not one of *dilution* alone.

At Landore some excellent specimens of steel were shown, also, which were made by the Siemens "ore process," at even less cost than the Siemens-Martin steel. This process will soon be patented in this country, and, for many localities, will probably be found the most valuable process yet introduced. The method had been regularly in use for several months at Landore, and very succfully, and the four new furnaces, now constructed especially for the ore process, are expected to give yet more favorable results. We are not yet at liberty to describe the details of the process.

One cause, undoubtedly, of the success of British Bessemer steel makers is the invariable employment of a professional chemist at the works, who analyzes carefully all stock received, and all grades of product. Frequently he makes a set of analyses of metal at various stages of manufacture, and thus keeps a useful check upon all employees, from purchasing agents to the workmen in the rolling mill.

A chemical test determines the value of all materials before purchase, and equally well whether a cracked rail is faulty in the character of the metal or from carelessness at the rolls, and as work is usually paid for "by the piece," the loss does not usually fall upon the employers if caused by ignorance or carelessness of employees.

The use of steel seems to be extending more rapidly in Great Britain than in the United States; crankshafts and other parts of the steam engine, screw propellers, and, to some extent, steam boiler and ship plates are made in steel. It is but a short time since manufacturers were unable to guarantee steel plate of greater thickness than ¼-inch, but good plate can be obtained now of any thickness that can ordinarily be used in either boiler making or shipbuilding, and a steel containing from 0·3 to 0·5 per cent. carbon is probably before many years destined to supersede wrought iron almost entirely. Such a steel has all of the ductility and malleability of wrought iron, combined with very much higher absolute tenacity and resilience. Its introduction renders many constructions practicable that were quite impracticable with wrought iron, and the coming "steel age" may present as great a contrast with the expiring "iron age" as is seen between the latter and the "age of bronze."

Analysis of British Ores and Irons.

ORES.

LOCALITY.	Cleveland Ore.		Staffordshire.		S. Wales.	Cumberland.
			S.	N.		
Protoxide Iron	39·92	43·02	30·96	46·53	40·30	.....
Sesquioxide Iron	3·60	2·86	.....	.....	.....	95·16
Protoxide Manganese	0·95	0·40	0·73	2·54	1·03	0·24
Alumina	7·86	5·87	0·13	0·97	1·43	.....
Lime	7·44	5·14	1·84	2·41	1·44	0·07
Magnesia	3·82	5·21	2·90	1·39	2·77	.....
Potash	6·27	.....	.....	.....	.....	.....
Silica	7·12	7·12	0·15	.....	.....	.....
Carbonic Acid	22·85	25·50	22·13	30·77	28·33	.....
Phosphoric Acid	1·86	1·81	0·26	0·69	0·88	trace.
Sulphuric Acid	trace.	.....	trace.	0·04	trace.	trace.
Bisulphide Iron	0·11	.....	0·12	0·34	0·09	trace.
Water	2·97	3·48	2·39	1·47	0·74	.....
Organic Matter	trace.	0·15	0·10	10·46	0·29	.....
Ignited Insol. Residue	1·64	0·05	37·90	2·27	22·48	5·68
	100·41	100·61	99·61	99·88	99·68	101·15
Metallic Iron	33·62	35·46	24·88	36·39	31·63	66·60
Authority	A. B. Dick.	A. B. Dick.	J. Spiller.	A. B. Dick.	A. B. Dick.	A. B. Dick.

IRONS.

LOCALITY.	Cleveland.		Staffordshire.		S. Wales.	Cumberland.
			S.	N.		
Carbon (graphites)	3·04	3·35	3·12	2·54	2·95	3·22
Silicon	2·73	1·57	1·16	2·71	1·96	3·02
Sulphur	0·04	0·04	0·05	0·04	0·28	None.
Phosphorus	1·30	1·38	0·44	1·07	0·63	0·06
Manganese	0·38	0·07	0·94	0·98	0·23	0·11
Nickel } Cobalt }	.....	.....	.....	.....	0·04	.....
Authority	Percy.	Percy.	Percy.	Percy.	E. S. Riley.	Abel.

Mechanics, Physics, and Chemistry.

ON CHLORAL HYDRATE.

By Robt. F. Fairthorne.

Amongst the most desirable additions to the list of medicines employed for the relief of the frail or diseased portion of the human family, a substance giving repose to the excited brain and body, procuring calm, refreshing sleep, and followed by no baneful effect to those using it, would be considered of the greatest value.

It has been said, "Blest is the man who first invented sleep." I do not suppose that he who finds the means for obtaining the same at pleasure is any less deserving of benediction.

In vain we look over the Materia Medica of our Pharmacopœia for a somnific that is both reliable and free from dangerous effect. We find opium, belladonna, aconite, morphia, fish-berries, chloroform, ether, digitallis, and stramonium; all reliable narcotics; but none of which can be taken without danger, and none without being followed by some evil influence.

Then, again, we find lactucarium, (lettuce opium,) hemlock, lupulin, hyosciamus, and valerian, (although occasionally efficacious and without deleterious properties,) are so unreliable that they are principally employed in cases of but slight indisposition.

Should we find, then, something combining in its character the reliability of the substances named in the first list, together with the immunity from evil characterizing those last mentioned, we would regard it with the greatest interest.

It would be premature, perhaps, to claim chloral as a perfect hypnotic, as it is scarcely two years since it began to be employed as a medicine.

It was discovered by Liebig, about thirty years ago, but remained as a scientific curiosity on the shelves of the laboratories of Europe until Dr. Liebreich, of Berlin, made known its value as an anæsthetic to the medical profession.

He was led to experiment with it, knowing that upon addition to an alkaline solution, the constituents of chloral are separated into chloroform and formiate of potash. The blood being slightly alkaline, containing as it does small quantities of the carbonates of

soda and potassa, suggested to his mind the probability of this reaction taking place in the human subject.

It is found, however, that hydrate of chloral differs in its effect from that of chloroform in not producing complete anæsthesia, except during a very short period (a minute or two) after having been administered, and this only when very large doses have been taken. This can be accounted for by the fact that the blood contains so minute a portion of the alkaline salts that when chloral is decomposed by it chloroform must be very slowly developed.

That this production of chloroform really takes place, I think there can be no doubt, as has been conclusively demonstrated by the experiments of Dr. B. W. Richardson, (F. R. S.,) before a meeting of the British Association at Exeter, England. He produced that article upon mixing the hydrate with freshly drawn blood and distilling the same. Previous to distillation chloroform was perceptible, so that it must be generated immediately on contact with the blood. (See *Medical Times and Gazette*, Sept. 4, 1869.)

Dr. Demarquay of the French Academy, however, does not agree with this theory, thinking that the hydrate of chloral penetrates the system unchanged, but the weight of testimony of those employing it is in favor of Liebreich's idea. I would suggest, however, the possibility of but a small portion of the chloral being split up, so as to produce only a minute portion of chloroform, and the remainder entering the body unaltered.

It is noticed that after full doses of this substance have been taken, there is a short space of time during which complete anæsthesia takes place, and, although sleep is prolonged several hours, yet entire insensibility is confined to but a few minutes. This may be due to that period during which chloroform is first produced, being that moment when probably the largest amount is formed.

The hydrate of chloral given in moderate doses (from 10 to 35 grains) usually procures sleep of seven or eight hours' duration, which in appearance is natural, and in effect refreshing. Neither the frequency of the pulse nor of respiration are usually altered by it. No disagreeable effects, except in very rare instances are perceived upon awakening, and even in these only slight headache and nausea follow, and which soon pass off. Even in quite large doses, (from 50 to 80 grains,) it seldom causes any unpleasant symptoms, upon the patient resuming consciousness.

Dr. Lincoln, of Boston, having a patient who had been without

sleep for a week, with the exception of an hour a night, and who had taken opium, valerian, lupulin, cannabis indica, and hyosciamus in vain, gave 15 grains of hydrate of chloral nightly, with the procurement of seven hours' sleep in each nocturnal period.

It appears to be the most perfect hypnotic known, and the above is only a fair specimen of numberless instances where its administration has been followed by equally good results. With the exception of one or two cases, in which very large quantities were accidentally taken, no evil has been caused by it. "*The Lancet*," of Nov. 26, 1870, gives an account of a patient who took 160 grains of the hydrate of chloral without any unpleasant consequences. Dr. Jas. Rodman reports in the "*American Practitioner*," Oct., 1870, that 270 grains were taken without any other alarming symptom than that of 18 hours' sleep; and in another case the enormous quantity of 460 grains was taken by mistake by a female nurse at the Philadelphia Hospital, producing effects resembling those of an overdose of opium. She was supposed to have taken that drug, and was treated accordingly; by which treatment she completely recovered.

Dr. Penrose, of the University of Pennsylvania, had a patient who took 210 grains (in divided doses in the space of two hours,) which was followed by 7 hours' sleep, and no unpleasant symptom except headache and stupor, which lasted several hours after awakening. He also states that he has given another patient from 5 to 10 grains nightly for a year, and finds that the lady taking it is as susceptible to its sudorific influence now as when she began to use it, not requiring any increase of dose. No bad effect has been experienced in this case, except an occasional disposition to produce lachrymose secretion and slight obscurity of vision. This superabundant secretion has been noticed by others who have used it for some length of time.

An intelligent lady of my acquaintance informed me that, her husband having had occasion to take chloral, she noticed it caused a profound sleep of two hours duration. His respiration was sometimes very irregular, ceasing for so long a time as to be quite alarming. Occasionally I meet with persons who inform me that this medicine acts as a stimulant and excitant, tending to keep them wakeful.

So far as I am able to learn, only one death has been ascribed to the use of chloral. The account is given of this case in the "*Medical*

Times" for February 15, 1871. A woman suffering from great mental excitement, almost amounting to insanity, took 180 grains in doses of 30 grains each, at intervals of several hours, during the period of three days. She died two days after the last dose was taken. Dr. Jas. Tyson, and other physicians who have read this report, think that there is room for doubting the correctness of attributing the death of the patient to the effect of chloral.

According to Dr. Liebreich, one fact connected with its therapeutic action worthy of attention is, that it possesses the peculiar and valuable property of neutralizing the poisonous effects of strychnia. Another singular property it possesses is, that, like chloroform, it nauseates birds when given to them.

Doctors Richardson and Liebreich state that chloral acts first on the volitional centres of the cerebrum, next on the chord, and lastly on the heart.

Hydrate of chloral as found in commerce occurs in two conditions. One form is that of tabular pieces of various sizes, having a crystalline structure, which, when freshly fractured, presents considerable resemblance to spermaceti. Another form is that of loose acicular crystals, shining and transparent when recently prepared, but becoming more or less opaque by age, even when kept in tightly stoppered bottles. I think this change is probably due to the action of light, as the vapor of alcohol, if exposed to sunlight in the presence of chlorine explodes, accompanied by bright flashes of light. Chloroform is also partially decomposed by light, chlorine and hydrochloric acid being developed.

Chloral is formed by passing dry chlorine through alcohol until fumes of muriatic acid are no longer given off and the spirit has assumed a yellow color. This liquid is heated until it boils. It is then mixed with three times its bulk of sulphuric acid and distilled, and finally redistilled over quick-lime.

Its formation appears to depend upon the affinity that chlorine has for hydrogen, the former gas taking it from alcohol, and being disengaged during the process as hydrochloric acid. Alcohol composed of $C_4\ H_6\ O_2$ by abstraction of two equivalents of hydrogen, (which takes place at the beginning of the process,) becomes aldehyd $C_4\ H_4\ O_2$. As the chlorine continues to pass, it takes with it three more equivalents of hydrogen, leaving, however, three of chlorine in their place; the aldehyd, therefore, is decomposed, and $C_4\ Cl_3\ HO_2$ remains, which is chloral. This is a volatile, pungent

liquid, of nearly the same specific gravity as chloroform, being 1·500, that of chloroform 1·490. It has a strong affinity for water, with which it combines, and with one equivalent of it, forming the hydrate just described. It also forms a crystalline compound by the addition of an equivalent of alcohol, which resembles the hydrate in appearance, but can be distinguished from it by being much less soluble in water.

Chloral, even when confined in hermetrically sealed tubes, after being kept for some time, gradually changes into a solid porcelain-like substance. When this is heated, however, it returns to the liquid state, and is of the same composition as previous to the change.

Pure hydrate of chloral, according to Dr. Rieckher does not take fire when heated in a spoon over a spirit lamp, but evaporates without residue. Solution of nitrate of silver should not be rendered turbid by it, thereby showing the absence of uncombined chlorine. Nitric acid, sp. gr. 1·20, either cold or hot should not produce any reaction with it. I find that it is readily soluble, when freshly prepared, in its own weight of water. After keeping and being occasionally exposed to the air it becomes less soluble, and sometimes its solution remains turbid for a few minutes after being made. With solution of subacetate of lead a dense precipitate is formed. The supernatant liquid becomes densely clouded upon further addition of the subacetate.

The hydrate is readily dissolved by alcohol, ether, oil of turpentine and benzole. It is also soluble in bi-sulphide of carbon and the fixed oils. The solution in the latter article might prove an important method in the hands of the physician for tapical application, perhaps available in neuralgia and gouty affections. I find that benzine also dissolves it slowly.

When hydrate of chloral is added to a strong solution of bi-chromate of potassa and heated after the addition of a few drops of nitric acid, the olive-green color peculiar to the alcoholic test is gradually developed. After standing, this becomes blue, and if liquid ammonia is afterwards added in large excess, it assumes a currant-red color. Chloroform treated in the same manner, produces a deep orange, retaining this color even after the ammonia has been added.

As an evidence of the growth in its popularity as a remedy, I will state that in January, 1870, the price of an ounce of chloral

was greater than that of a pound at present, and that the last named quantity is at present consumed by druggists in compounding physicians' prescriptions in the same space of time as was required to dispose of an ounce at that period.

There are other methods for preparing chloral than that referred to in this communication. I would merely say that chlorine acting upon substances capable of undergoing the alcoholic fermentation will produce it.

ON THE USE OF HYDRAULIC MORTAR.

[Translated from "Die hydraulischen Mörtel" of Dr. W. Michaelis, for the Journal of the Franklin Institute.]

By ADOLPH OTT.

(Continued from page 285.)

MANGER proposes the following excellent and simple experiment to ascertain the comparative quality of various descriptions of sand. He advises to form small heaps of sand on the bottom of a flat vessel, to pour water carefully around their base, and then to observe how the water rises in the heaps. Is the surface clean, the water will rapidly penetrate the sand in all directions, while if it contains earthy or clayey parts, the process will be much slower.

Wherever the sand at the disposal of the builder is found not to be sufficiently clean, it has to be washed; large quantities are best cleaned in vessels of $0^m \cdot 3$ to $0^m \cdot 5$, in lime chests, for instance. The sand must be thoroughly stirred up in water, and the latter then be rapidly drawn off, to be replaced by clean water, which experiment has to be repeated until the water flowing off appears clean.

Where sea-sand is used for structures above the water level, it must be carefully washed, in order to remove its saline parts, which would produce a strong effervesence.

All admixtures possessing considerably less hardness and solidity than quartz-sand, which soften in water, or become soluble in it, must be strictly avoided.

Pulverized glass, brick-dust and other substances have sometimes been used as substitutes for sand. Inasmuch as the first named materials possess an affinity to the quick-lime of the mortar, they may

safely be resorted to where sand cannot be obtained, as they acquire considerable hardness and solidity, provided the brick-dust is of bricks burned hard.

Van Helmont and Kunkel already knew that glass is not altogether inaccessible to wet chemical agencies, and Scheele showed in the preface to his work "The Chemistry of Air and Fire," how considerable an influence is exercised upon glass by boiling water. His experiments, however, like those of Lavoisier, Chevrèul and Barral, were confined to the influence of this agent upon glass vessels.

Taken all in all, this influence is only very minute. Lavoisier shows, for instance, that after an uninterrupted distillation of one and the same volume of water (which always flowed back into the retort), the loss of the vessel after 100 days was not quite one gramme; the influence of cold water upon compact masses of glass is still more insignificant. But it is different when pulverized glass is exposed to the action of water. Pelouze has made (in 1856) some highly interesting experiments in this direction.

Pelouze asserts, that a retort of the capacity of 500 C. C., in which water is boiled for five days uninterruptedly, hardly loses $0^{gr.}\cdot1$ in weight; but if the neck of the retort is broken off, pulverized and exposed to the influence of boiling water for the same length of time, the decomposition of the glass reaches nearly one-third of the entire quantity.

On the other hand, the same vessel, after containing water for years without being perceptibly changed, will, when pulverized, undergo a loss of from 2 to 3 per cent. by dissolution, when exposed to cold water only for a few minutes.

All glasses which form articles of trade, like looking-glass, window-glass, bottles, crystal and flint-glass, decompose gradually when pulverized and exposed to the air by absorbing carbonic acid; after a short lapse of time they effervesce vividly with acids, the development of carbonic acid becoming so great that one might be induced to believe he had a quantity of chalk before him.

If pulverized glass is boiled in water, and carbonic acid introduced, this gas is completely absorbed within a short time.

Griffith showed in 1826 that pulverized glass instantly imparts a blue color to litmus-paper and tincture; a proof of the immediate decomposition by water.

The facility of decomposition of glass by water alone shows that

pulverized glass forms an excellent admixture for lime, and that hydraulic mortar can be made with glass just as well as with trass and puozzolana. This has been proven by all experiments which we have made with pulverized looking or window-glass.

Moreover, Fuchs already says, that common glass is preferable to pitch-stone or pumice as an admixture to lime; it combines but slowly, it is true, but it finally gives a product which in solidity almost equals marble.

The same may almost be said of brick dust.

All descriptions of burned clay are known to be highly effective puozzolanas. Brick-dust, however, is nothing else but burned clay with a greater or smaller admixture of sand, which, from a chemical point of view, must naturally be considered as inert.

As regards the quantity of sand which may be admixed to hydraulic lime, it is dependent on the nature of the lime and cement, and on the object immediately in view.

It is impossible to lay down strict rules for guidance in such cases, especially not for the preparation of hydraulic lime.

In all cases, an experiment must be resorted to, to ascertain what mixture answers best for the object to be attained.

Portland-cement may be mixed with three to four times its quantity of sand, but this must be considered the extreme limit wherever it is intended for use in solid structures.

Considering that the intermediate space in sand amounts, on an average, to four-tenths of its volume, and that a compact solid mortar can only be obtained if every grain of sand is imbedded in a certain quantity of lime or cement, an admixture of three times the quantity of sand to one volume of lime or cement must appear to be the outside figure. Nevertheless, cement has often been mixed with a greater proportion of the admixture.

The slower the process of setting of pure cement, and the greater solidity it is capable of acquiring in itself, the greater proportionate admixture of sand it may be subjected to, as has been proven by numerous experiments.

Professor J. Manger says that by the mixture of

1 hectol.	cement					and	0	hectol.	44	water	—0	hectol.	91	mortar	is	obtained
1	"	"	1	hectol.	sand	"	0	"	66	"	—1	"	83	"	"	
1	"	"	2	"	"	"	0	"	88	"	—2	"	78	"	"	
1	"	"	3	"	"	"	1	"	20	"	—3	"	80	"	"	
1	"	"	4	"	"	"	1	"	65	"	—5	"	01	"	"	

while according to Becker—

1 hectol.	cement					and	0	hectol.	·66	water	produce	1	hectol.	·00	mortar.
1	"	"	1	hectol.	sand	"	0	"	·56	"	"	1	"	·48	"
1	"	"	2	"	"	"	0	"	·80	"	"	2	"	·20	"
1	"	"	3	"	"	"	1	"	·06	"	"	3	"	·08	"
1	"	"	4	"	"	"	1	"	·26	"	"	3	"	·90	"

The considerable difference in the above statements would not, in itself, surprise us, as we know by experience that the quantity of water required for the production of consistent mortar depends, in a great measure, on the peculiar nature of the cement; but what appears indeed remarkable is, that in the series of investigations by Becker, the pure cement requires one-half more water than is set down by Manger; while, on the contrary, his mixtures with sand show a smaller quantity of water than appears in the statement of Prof. Manger.

In fact, the figures which follow below show, irrefutably, that Becker must have been misled in his experiments with pure cement.

If we assume that 100 parts of pulverized cement combine chemically with 19 parts of water, the solid mass is calculated as follows:*

0 hectol.	·91	mortar	of	the	series	of	experiments	by	Manger	at	0	hectol. ·70
1 "	·83	"	"	"	"	"	"	1	"	·42		
2 "	·78	"	"	"	"	"	"	2	"	·13		
3 "	·80	"	"	"	"	"	"	2	"	·83		
5 "	·01	"	"	"	"	"	"	3	"	·59		

From this we deduce a proportion of denseness of—

100	:	76·9,	while,	according	to	Becker,	the	proportion	would	be—	100	:	57·		
100	:	72·1,	"	"	"	"	"	"	—	100	:	77·7			
100	:	73·0,	"	"	"	"	"	"	—	100	:	75·2			
100	:	74·5,	"	"	"	"	"	"	—	100	:	73·0			
100	:	71·6,	"	"	"	"	"	"	—	100	:	73·6			

If we leave the first of Becker's experiments out of the question, as it undoubtedly errs in the figures given, we find that the denseness of cement mortar is not increased by the admixture of sand up to three times its quantity, but is rather somewhat diminished.†

* One hectolitre pulverized cement weighs 121·3 kilo.; 23·05 kils. are consequently equal to 0·23 hectolitres.

† We speak here of admixtures of sand within the limit of 1 to 3 parts sand to 1 part cement; because, as we have mentioned before, the admixture of 3 parts sand must be considered the outside limit; if a greater proportion of sand is added, the denseness of the mortar will invariably be reduced. This has also been plainly proven by the experiments of Manger.

Experience has universally confirmed this proposition; we only know of one case where experiments had essentially different results; this was at Hâvre, where, since the construction of the docks was commenced, numerous experiments have been made, and it has been found (as reported by Dulk) that a mixture of one part of Portland-cement of White & Son and of J. F. Knight, with two parts of sand, produces the most solid and the densest material.

The report says: Since the construction of the dry docks has been entered upon (towards the end of 1858), constant experiments have been made on the building-ground to ascertain the precise quality of Portland-cement and the most advisable mixture, as it was also intended to make use of this material for the preparation of beton.* From each ton which had to be examined, a certain quantity of cement was taken, mixed in diverse smaller parts with various quantities of sand, and the mixtures put into brick forms. Each one of these was carefully marked with the date of the experiment, the description of the cement used, and the quantity of sand admixed. Of the product of each mixture two corresponding samples were kept, of which one was exposed to the air, the other to the influence of water for the purpose of hardening. After a certain lapse of time, dependent on the proportions of admixture and the degree of hardness to be obtained, the cohesive power of the samples, formed like a T, was first tried; then their comparative denseness was ascertained.

Small cylinders, of a diameter of $0^m \cdot 10$ to $0^m \cdot 15$ in height were formed, marked and numbered like the other samples, always two corresponding samples at each experiment, one of which was immediately laid under water, while the other was exposed to the air.

When the trial was made after a certain time, each cylinder was screwed in between two brass covers, closing so hermetically that no water could possibly penetrate between the covers and the cylinder. The upper cover had a hole in the centre into which a lead pipe, in connection with a higher situated water-reservoir was inserted; each one of the cylinders was thus subjected to the pressure of a water column of 5^m. Under each cylinder a tin box was

* As the pressure of the water is very great, the entire construction rests on a beton-layer, which has a thickness of $3^m \cdot 58$ in the middle, where only Portland cement has been used; this material has likewise been exclusively used at those parts which are mostly exposed to the pressure of the waves, while at other parts ordinary hydraulic lime was taken.

placed, into which all the water pressed through their sides had to flow.

After a considerable time, the water which had thus accumulated in the tin boxes was separately weighed, and the comparative proportion of denseness ascertained.

The result of all these tests are the following:

"A mixture of one part of Portland-cement with two parts of sand produces the most solid and dense mortar."

This, however, is so entirely contradictory to all experience that we are induced to believe no mixtures with other material but sand were ever tried at Hâvre, and that, as the proportion of two to one was the lowest quantity of sand admixed, it proved to give the best material.

(To be continued.)

PENNSYLVANIA'S FOUNDATION STONES.

Lecture delivered before the Franklin Institute, Thursday, Dec. 22d, 1870,
By PROF. LEEDS.

The Position of Pennsylvania in the Geological Scale.

A CONTINENT was slowly sinking beneath the level of the sea. It was carrying down with it the fabric of an ancient world: a world of which we know but the little that can be gathered from the few fragments which remain. It was a world of granites and syenite, diorite and basalt, greenstone and porphyry—solid, compact and flinty. It was a world of wealth, of riches incalculable, but those riches were so locked up with bolt and bar, so fastened into the unyielding structure of the rock, so combined in obdurate compounds, that no strength of arm or even the chemist's skill could unlock them. It was a world of strength. Iron was there. Lead, copper, zinc, tin, were there. But, if mighty furnaces, that tower to the skies, and tax whole provinces for fuel, with difficulty extract from the pure ore its metal, how vain would be all man's toil, how hard and hopeless his lot, if nature had not already done for him the work of extracting these ores from the stony matrix. It was a world blessed with food and fertilizers of every kind. Almost every rock had potash and lime. The materials for plant and flower existed there—but hardly to be recognized—as stone. Enough, too, of sulphur and phosphorus, and phosphoric acid, to make all the nerve and fibre that plant and animal shall ever need,

but so united with harder stuff, so bound down with metal chains, that it would seem vain to hope that they could escape from bondage and rise to their appointed destiny.

But from the sea new life is born. So sang the Greek poets, and what then was a mere myth is found to be a sober truth of science. Time, so sang the Grecian seer, slew the god that in the beginning ruled over all things, named Uranus. He put an end to the heavens that were, to the order of things, then existing, and cast their remnants into the sea. From these remains sprang Aphrodite, whom the Romans, with their coarse and more brutal intellects, called Venus—the goddess that typified the reproductive and fertilizing energies of the earth. Do not your imaginations recall the exquisite picture—where the new-born goddess, with dainty arms raised above her head, and golden hair sparkling with pearly dew-drops, and eyes that languish love, is rising from the sea, her tiny foot just poised upon the crest of the waters.

The first continent that divided the waters from the waters was buried again in the sea, and from its ruins sprang all that ministers to or enjoys life.

I doubt if anywhere there exists at the present time a relic of this antique world of which I speak; at least, none whose claim to so great antiquity cannot reasonably be doubted. I think that all of us would give much to stand upon some fragment of this world. We know full well the interest with which we wander among the ruins of some ancient city. We examine curiously the marks of shot and shell which chronicle a bombardment of comparatively recent years. The narrow loop-holes in the watch-tower and the massive city gates carry us back to the middle ages. A few huge stones, that two thousand years have not been able to pull asunder, tell of the massive masonry of the Romans, while spears and hatchets of copper or of stone which have been dug up from beneath the soil, transport us to the infancy of the civilized races. But to stand on a spot that stood above the waters before any of these existed, before even the first beginnings of life itself, that were worth more than all—from this eminence to look down through the long ages, and behold country after country emerging from the deep, new forms of vegetable structure and higher types of animal life make their appearance, until man himself appears upon the scene, and the end of all things earthly approaches.

If any such spot exists, it is to be found on the American conti-

nent, and follows the present course of the St. Lawrence river and the boundary line which separates Canada from the United States. There we find a broad band of primitive rocks, granite, gneiss, syenite, hypersthene rock, porphory, labradorite, stretching to the northeast until it terminates upon the coasts of Labrador, and to the northwest towards the Arctic Ocean. Some few outlying tracts, such as the triangular area included between Lake Champlain, the St. Lawrence and Lake Ontario, a part of Wisconsin and Minnesota, the Iron Mountains in Missouri, and the Ozark Mountains in Arkansas, may possibly date from the same remote period.

It is full of mineral wealth. It contains quartz, felspar of many kinds, hornblende, pyroxene, epidote, mica, crystallized in some localities in plates one and two feet square, talc, garnet, tourmaline, scapolite, wollastonite, sphene, rutile, graphite, apatite, chondrodite, spinel, zircon and corundum, and iron in greater abundance than in any of the rocks of later geological age.

I say that it is to be doubted whether these areas belonged to the ancient world—the world which crystallized out of the fiery mass of which I have spoken in my last lecture—for these Canadian rocks, the Laurentian Hills, as they are called, are made up of layers, one resting upon another. Granite succeeds gneiss, and gneiss reposes upon schist and limestone. Between these layers are other layers of iron ore, some of them a hundred feet and upwards in thickness, which are banded with silicious layers and chloritic schist, showing thereby a distinctly stratified character. Through all subsequent ups and downs of fortune, through every change and mutation, the evidence of this original layer condition of the strata has persisted, and may be recognized over great areas where the layers have been creased and twisted, and folded one upon another, until what has originally been horizontal has become vertical, and what was once the upper has become the lower surface of the layers.

There are some who see in these rocks the results of igneous action—products of the furnace, ashes turned out from the pit. Says Agassiz: "It may be asked how the materials for those first stratified deposits were provided? In later times, when an abundant and various soil covered the earth, when every river brought down to the ocean, not only its yearly tribute of mud or clay or lime, but the *débris* of animals and plants that lived and died in its waters or along its banks, when every lake and pond deposited at its bottom, in successive layers, the lighter or heavier materials

floating in its waters and settling gradually beneath them, the process by which stratified materials are collected and gradually harden into rock is more easily understood. But when the solid surface of the rock was just beginning to form, it would seem that the floating matter in the sea can hardly have been in sufficient quantity to form any extensive deposits. No doubt there was some abrasion even of that first crust; but the more abundant source of the earliest stratification is to be found in the submarine volcanoes that poured their liquid streams into the first ocean. At what rate these materials would be distributed and precipitated in regular strata it is impossible to determine, but that volcanic materials were so deposited in layers is evident from the relative position of the earliest rocks." There are "innumerable chimneys perforating the Azoic beds, narrow outlets of Plutonic rock, protruding through the earliest strata. Not only are such funnels filled with the crystalline mass of granite that flowed through them in a liquid state, but it has often poured over their sides, mingling with the stratified beds around. In the present state of our knowledge we can explain such appearances only by supposing that the heated materials within the earth's crust poured out frequently, meeting little resistance—that they then scattered and were precipitated in the ocean around, settling in successive strata at its bottom—that through such strata the heated masses within continued to pour again and again, forming for themselves the chimney-like outlets above mentioned."

The great objection to such an explanation is that it calls for the operation of forces entirely different from those which were concerned in the making of other rocks precisely analogous in their character. As we shall see, later, the entire thickness of the rocks which now cover the United States, and which, along the line of the Appalachians, amounts to the stupendous aggregate of 7 miles, or 10,000 feet more than the height of the tallest mountain now existing, was deposited quietly at the bottom of the sea. I do not mean that a sea 7 miles deep was quietly filled up until the entire surface of the United States made its appearance along with the last layer essential to its completion. Far from it. These 7 miles are made up in the main of hardened mud, consolidated sand and compacted limestone, alternating one with another in beds of layers which vary in thickness from a few inches to very many yards, and in extent from a few square miles to the dimensions of one or more states. Now, it is doubtful whether any limestone is deposited on a bottom

deeper than a thousand feet below the level of the sea, or mud where the depth exceeds two or three hundred feet, while sandy beds were formed, as we may see any day for ourselves, directly upon the shores of the rivers and the seas. Such *sedimentary* beds, as they are called, may be traced without any gulf or break from those which are being formed at the present time, and which are preserving in themselves the bones of the shipwrecked mariner, the spars and timbers of the stranded bark, the skeletons of plants and animals now existing, to other beds which entomb the remains of creatures that existed just prior to the advent of the human race. Beneath the last are others still less recent, filled with huge saurians, reptiles that dragged their horrid slimy length through shallow seas, or waged desolating war upon the inhabitants of marshes. Thence to times when much of the temperate zone, and Pennsylvania more particularly, was covered with a magnificent growth of club-mosses, equisetaceæ, and gigantic ferns. And even after we have arrived at the lowest forms of animal life, and find in the sediments mere molluscan remains, we discover in the nature of the rocks or sediments themselves so slight a clew, that there is no problem in geology more difficult or more warmly mooted as to which sediments are fossil-bearing, and those which are destitute of all organic remains. There is an area which begins in Pennsylvania with the Edge, South Valley and Conewango Hills. It broadens as it stretches southwards, and extends from a point to the east of Richmond until it reaches the base of the Allegheny Mountains. It includes all of the centre and western part of North Carolina, the hill country of South Carolina and the northern part of Georgia and Alabama. Your excursions about the city have made you familiar with the rocks which spread over this immense area. They are principally gneiss, or gneissoid in their character. That is, they are composed of quartz, mica and feldspar, arranged in layers. This layer-like arrangement, let me say more particularly, is the great characteristic, the minerals varying excessively. For sometimes the quantity of quartz or feldspar, and more especially the latter, is very small, and not unfrequently it is lacking altogether. Sometimes the quartz is milky and compact, at other times it looks like cracked and hardened jelly. The feldspar is often white and mealy, and then again there are places where you can pick it out in large flesh-colored slabs. Black mica, transparent mica, mica in spangles mica in great plates, mica scattered through the quartz, or feldspar

and mica massed together in beautiful crystals, all of these varieties, and more, too, can be found in the region of which I have spoken. I do not attempt to exhibit them here, because it would be as unsatisfactory to so large an audience to have their attention called to things which can only be seen plainly when held closely to the eye, as it would be to devote the valuable time which we can spend together to these minor details. But a stroll through our beautiful Park, and an examination of the rocks where they are exposed along the banks of the river, will give you an hour's pleasant occupation, and amply confirm all that I have said.

When your summer trips, for recreation or study, shall take you to the extreme southern border of this familiar rock province, you will be delighted to recognize in the romantic valley of Asheville and the French Broad river, and through the gap of the Swananoah, and around the bases of Mount Black, Mount Mitchell, and the eight sister peaks, just such mica, schists, and gneiss as you have hammered to pieces while geologizing in Delaware and Chester counties.

And here let me say a word concerning the powerful influence which the geology of a country, consciously or unconsciously, may have upon our home associations. The trees in the temperate climates, its beeches, oaks, maples, poplars, willows, pines and birches, are pretty nearly the same the world over. But the underlying rocks are very different, and I have always felt a great step nearer home, even though, when measured by the road, the way were longer, when I stepped off the fossil-bearing rocks, and found myself treading upon granites and schists and quartz rocks. And I distinctly remember with what pleasure, after fishing for weeks in the headwaters of the Roanoke and the James rivers, I left the great ledges of red sandstone belonging to the Devonian rocks of West Virginia, and found myself looking for minerals among the more home-like micaceous rocks of North Carolina.

These gneiss rocks of South-eastern Pennsylvania, and the gneiss country stretching, as we have already seen, so far south-westward as Alabama, are concealed from our view, as we go to the north-east, for a distance of 90 miles. They appear to have been depressed, probably at the time of the great disturbances which occurred, towards the close of the carboniferous period, over the whole of Eastern Pennsylvania, and probably a much wider area. The Atlantic Ocean rushed in over them, and their place was occupied by

a great gulf, the only vestiges of which at the present time are Delaware Bay and the harbor of New York.

A similar narrow gulf extended from somewhere about the southern State line of New Hampshire and Vermont, southward through Massachusetts and Connecticut, occupying nearly one-half the latter State, and vastly more than the present valley of the Connecticut river.

These areas were slowly filled with lagoons and bayous, with marsh and morass, and were the homes of the most grotesque and formidable monsters that the world ever saw. Where now the quiet-loving inhabitants of Moorestown and Haddonfield, and the busy population of Phœnixville enjoy the mild serenity of uneventful lives, lizards and saurians of gigantic dimensions, some of them exceeding 40 feet in length, ran and paddled about.

On the eastern side of the Hudson, with the exception of the gulf of Connecticut previously mentioned, these gneiss rocks are found once more upon the surface, and continue on through New England and Nova Scotia to the Gulf of St. Lawrence.

After this lengthy explanation, we must return to our argument, which, as you will remember, was intended to show the improbability of the supposition that the similar rocks of Canada and Northern New York were the stratified deposits of submarine volcanoes.

For it is, as I said before, with the greatest difficulty that the micaceous schists of Eastern Pennsylvania which contain no relics of animal and vegetable life can be separated and distinguished from those which do. And the same remark applies to the rocks of New England, and even of those rocks in Canada whose origin, whether from fire or from water, we are discussing.

The tendency of all the investigations which are being made at the present time is to lengthen out the period during which animals and plants have existed upon the face of the globe, and to include more and more of the rocks which were formerly regarded as Azoic among the life-containing. The rocks of Canada, and, still better, those of South-eastern Pennsylvania, afford a field for the study and settlement of this extremely interesting question—a better field, perhaps, than the rocks of any other portion of the earth's surface. The first great step, indeed, towards its solution was made through a careful scrutiny and a more critical examination than heretofore of the Canadian rocks, the rocks which, as I have previously said,

approach more nearly than any others to those which constituted the first formed solid crust of the globe.

They are divided by Sir William Logan, the Government Geologist of Canada, into the Laurentian and the Huronian. The former derive their name from the low line of the Laurentian Hills, and stretch, as I have previously mentioned, north-eastward to Labrador and north-westward to the Arctic Ocean. The Huronian include only a narrow band on the borders of Lake Huron, whence their name, and along the northern shores of Lake Superior. They are made of slates full of flint, of schists, massive quartz rock, limestones, and mixtures or conglomerates.

Their total thickness, according to Sir William Logan, is over 12,000 feet. If we add to these the Laurentian, which are probably 25,000 feet in thickness, we have the stupendous aggregate of 37,000 feet, or nearly as great a thickness of sedimentary rocks, deposited, as we have seen, at the bottom of the sea, during a time in which no life existed upon the globe, as of sedimentary rocks deposited later, at a time when it did.

And if we are to accept the theory of their igneous origin, we are compelled to believe in this enormous ash-heap, 37,000 feet in thickness, thrown out upon the bottom of the ocean. Thrown out, too, mark you, not only where we can see them as we do in Canada, and as some have believed, in Eastern Pennsylvania and along the entire eastern slope of the Appalachians, but everywhere forming the bottom of all the seas which exist at the present time, and concealed beneath the surface of all the continents.

Every year has witnessed some advance in our knowledge of the materials that make up the crust of the globe, which has weakened the probability of such a tremendous activity on the part of submarine volcanoes.

In the first place, although these rocks are largely made up of granites, quartz, marbles and other stones, which in some cases undoubtedly arise from the fiery mass filling up the interior of the globe, since they are found protruded through the most contorted cracks and dykes and fissures, which seem to split right down through the sedimentary rocks to the earth's core, yet the granites and quartzes alternate with mud, rocks and compacted sand. And what is still more at variance with the supposition that these granites and quartzes of the Azoic beds are furnace products, is that the quartz and feldspar and mica which, irregularly mingled to-

gether, constitute granite, assume more and more of a layer-like arrangement, until you pass by steps so numerous and so small that you cannot separate them, from a true granite to a true gneiss. And in the same way, from a hard flinty quartz to a sandstone, which looks as though made up of sand dug up from the sea shore. And from a highly micaceous schist to a hardened mud rock or slate, such as is now forming when every ebb tide brings down from the rich fields of Bucks county some of its soil and deposits it along the shores of the river.

A still more striking proof of the watery origin of these hitherto so-called Azoic beds is one which recently came under my notice. You may examine the matter for yourselves, by taking, any pleasant afternoon, a quarter of an hour's ride upon the Germantown Railroad, and getting out at Wayne Station. There you will find, on walking a few rods, until you arrive at the point where Wayne street cuts through a low hill, a most remarkable rock formation. The strata have been folded first into a deep trough, and then the sides and top of the trough have been squeezed together and folded one upon another, and finally twisted until one side of the trough is found above and the other beneath. So much for the curious phenomena, which I have examined many a time, and always with fresh interest.

(To be Continued.)

ON THE BALLOON AS AN INSTRUMENT IN METEOROLOGICAL RESEARCH.

(An abstract of a paper read before the Franklin Institute.)

By JOHN WISE.

IN the study of meteorology there is one means of investigation which is capable of marvellous development, and which, as yet, has not received a tithe of the attention of which it is worthy. I refer to the balloon. Meteorology has as yet but feeble claims to the name of Science, nor, until some mode of research is devised that will bring the student of atmospheric phenomena into closer relation, into more direct contact with the problems he would solve, can we hope for more rapid progress than we make at present. The air-ship must furnish us with the solution of the problems, at which we can now but venture to guess—for it is the only means which is com-

petent to meet the imperative wants of the investigator; it alone can bring him face to face with, and in the very midst of the mysteries of his subject. It is to meteorology what the water-ship is to hydrography, and in their respective departments one can be as little dispensed with as the other. The little that we know of the subject serves as far as it reaches to justify the comparison. The deep sea soundings, so pregnant with interest in their revelations of infusorial life at the bottom of the ocean, have been met with the deep air soundings, revealing to us vegetable myriads, which make the upper air their highway.

Is it not a marvel then that a field ripe for the sickle waited so long, and waited in vain for the harvester? It will be objected that the mode of investigation is a dangerous one; but, with the experience of many years to warrant the assertion, the writer feels safe in stating that this opinion is wholly erroneous. It has its origin partly in the novelty of the means employed, and partly in wilful misrepresentation. If one who is interested in the subject will take the trouble to institute a comparison between the number of recorded air voyages and the accidents incident thereto, a result will be obtained as favorable as the most sanguine admirer could claim for ocean travel. As an extreme instance, the following may be of service to meet the objection under consideration. The writer has circumstantial accounts of thirteen balloon explosions (in two of these he was a participator) which occurred at considerable elevation—from 5000 to 15,000 feet—and in none of these instances were any of their occupants harmed.*

* On the 11th day of August, 1838, the writer made an ascension from Easton, Pa., with preparations to explode his balloon, for the purpose of demonstrating that an exploded balloon would form a *parachute*, and thus descend with its occupant without serious injury. Accordingly, when an altitude of about 13,000 feet was attained, the balloon became fearfully expanded—to its utmost tension; and, having a neck tube but an inch diameter for the lower safety valve, the gas began to issue therefrom with considerable noise. The *exploding* cord (an invention of the writer) being tied short, had also become tensely stretched, and was tending towards a rupture. At the points it passed through the top of the balloon. As the ship was at the time immediately over a thundergust raging some eight or ten thousand feet beneath, it was with considerable trepidation that the critical experiment of the explosion was decided upon. Taking out his watch, twenty minutes past two was noted on the log-book, and as it was returned to its fob, the *balloon exploded*. The gas rushed through the large aperture, ten feet long, with a tempestuous noise, and in ten seconds the balloon was empty. The descent was rapid at first, but the ship soon came to a uniform velocity, and the landing was effected safely in a clover field, after having crossed a piece of wood land by dis-

The law of atmospheric resistance is as invariable as that of atmospheric buoyancy, and with the large expanse of material present in a balloon, and the very nature of its construction, it is scarcely conceivable that in falling it should offer so little resistance as to descend with destructive or even dangerous speed.

Nor is the ship, even under such unusual circumstances, unmanageable. So far as the writer has investigated the cause of accidents with balloons, not a single instance was found to be assignable to any dangerous element peculiar to, or connected with the art of ærial navigation. The water-ship has two elements with which to contend—the water, nearly a thousand times denser than air, the winds, with the velocity at times of an hundred miles per hour; these, combined with the immense mast leverage, must cause terrific strain upon its framework when in the grasp of the storm.

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posing of ballast, and drifting with the wind. As near as the descent could be timed, it occupied four and a half minutes.

The following curioue note was received next day. The writer was a stranger.

"NEW VILLAGE, August 11th, 1838.

"Mr. Wise, Master of the Aerial:

"I hereby certify, that my first sight of your air-ship was north of Henry Snyder's; it then apparently passed not far from William Kinney's, then directly between the inhabitants of New Village and the sun; we saw the gas rushing from the balloon like the steam from a boiler; it created between us and the sun the colors of the rainbow, and it was some time before we got a second sight, when you appeared to be lowering. As the size of the balloon became larger, we could discover a black spot underneath, about twenty feet. I pursued on foot until I saw you alight near Thomas Thatcher's.

"From your most affectionate, but not acquainted friend,

"WILLIAM SHARPS.

"N. B. and others."

In the month of October following the writer repeated the experiment from Philadelphia. It was publicly announced to take place from the corner of Seventh and Callowhill streets. Prof. Mitchell, of Jefferson Medical College, strongly advised the omission of that part of the announcement, but the author mentioned in reply his confidence in atmospheric resistance, and his determination to repeat the experiment. The following is one of a number of newspaper notices of the occurrence:

"Mr. Wise, the æronaut, made a successful ascension on Monday (October 1st, 1838). The balloon passed over the Schuylkill, and Mr. Wise eventually descended, according to his promise, by letting off the gas gradually [this is a mistake, it was let off suddenly,] at an extreme height, by means of a cord and pulley, [there was no pulley, it was simply a cord to rip the balloon with at its top,] he converted the balloon into a parachute, and thus came down. It was a most fearful undertaking, and was anticipated by competent scientific authority as calculated to carry with it destruction of life."

Not so with the air-ship; it has but one element to conquer, and once freely suspended in the ocean of air, it matters not, so far as its capacity to withstand a strain is concerned, whether the wind moves at the rate of one mile or one hundred miles per hour. Even with the latter velocity, the vessel glides along so smoothly that a cobweb suspended from its flagstaff is undisturbed by the slightest ruffle. Were it not for the fact that objects on the earth are seen to approach and to recede, it would be impossible to detect the motion of the ship, with such marvellous stability and quietude is even this immense velocity accomplished.

The same rules which apply in securing safety to our ordinary mode of voyaging are ample in the method under consideration. The accidents which occur with balloons are in every case attributable either to deficient construction or to an absence of ordinary skill and prudence in the persons operating them. It is a deplorable fact that, with rare exceptions, those who are adepts with the balloon are not scientific, and it is this class who are especially fond of relating marvellous accounts of their physical agonies—of the fantastic tricks of their vessels, and their hair-breadth escapes. Let me hope that sufficient has been said and accomplished to prove that we can ascend into the air, into the cloud, into the storm, by day or by night, to investigate the phenomena of the atmosphere, without incurring the accusation of being reckless if we but turn our eyes of yesterday, when high officials of state sail from beleaguered cities in the air-ship, and governments use them as mail route agencies to distribute their daily mails.

To the Franklin Institute should the honor be assigned of establishing a Section of Meteorology, to explore the mysteries of the atmosphere with the aid of the air-ship and suitable apparatus. The cost of construction with modern facilities has ceased to be a drawback, and the establishment of gas works has greatly lessened the expense and inconvenience of inflation. And with such men as Dr. Wahl, our efficient Secretary, and his co-laborers in science, to undertake the investigations, and with an experienced air navigator to command the ship, a year would suffice to collect a series of facts which might go far toward deciding authoritatively matters which are now obscured in the mists of doubt and uncertainty. The services of the writer—if his experience is deemed of avail—would be most cordially offered.

We owe such a course of investigation to the age in which we

live. The progressive spirit of science demands earnest toil from her disciples, and calls for generous nourishment from institutions of learning, and none are better fitted to meet her claims than the Franklin Institute.*

Once properly put in motion, it would not be long before those who now scout the idea of crossing the oceans and circumnavigating the globe with balloons would be as solicitous to make their tours of recreation and scientific investigations in them as they are now to doubt its feasibility.

OBSERVATIONS ON SIEMENS' UNIT.

By F. Kohlrausch.†

The universal adoption of a galvanic unit of resistance will be decided by its introduction into and general acceptance in telegraphy; and there is little doubt but that here Siemens' mercury unit will hold possession of the field. The benefits accruing to scientific galvanometry by the introduction of his readily comprehensible and convenient scale of resistance has received general acknowledgement and praise. It may therefore be regarded as meeting that solution of the question of resistance which, in the discussion of the subject by the British Association, so many eminent physicists regarded as desirable. There exists, consequently, in the interests of Physics, the pressing need of fixing with all possible accuracy the relation between Siemens' and Weber's absolute unit. To the last mentioned scientist we are indebted for four methods of determining absolute resistance according to Ohm's law. Three of these methods were applied by Weber himself, while the fourth has been brought into use by the investigations of the British Association, instituted to determine the absolute unit.

The first method consists in making use of the electro-motive force induced by the earth's magnetism in a conductor in motion, the dimensions of which are given. The strength of the current is

* A meteorological section has for some time been organized in connection with the Institute, and has been very warmly supported. The object which the author so ably advocates may, when the resources of the section have grown sufficiently to warrant the undertaking, be practically carried into execution.—W. H. W.

† From the Reports of the Royal Academy of Göttingen, November 23d, 1870.

determined by the deflections of a small magnetic needle of known oscillating capacity, suspended within the coils of a galvonometer of known dimensions.

In the second method a galvanometer is employed within which a larger magnet oscillates. If we have ascertained the time of oscillation of the needle; if likewise by observation of the deflections of another needle we have ascertained the relation existing between the magnetism of the needle and that of the earth; and if the capacity of distribution of the former is known, it is evident that the electro-motive force created in it by the needle may be calculated, as from the dimensions of the galvanometer. The strength of the current hereby induced may be estimated by the observed steadiness of the needle.

The third method demands a knowledge of the coil surface of an earth inductor, and the absolute intensity of the earth's magnetism; and an astatic needle oscillating between close coils serves as a galvanometer.

In the last method, a bobbin of known dimensions is set in rapid and uniform motion, and the deflection of a needle suspended within, is observed.

Weber has used the first and second, and lately the third method, to determine absolute resistances. The last has been brought into use by the standard commission of the British Association. Concerning this fourth method the following may be added. It has, namely, two modifications: the inductor may be rotated either about a horizontal or about a vertical axis, and in either case difficulties are combined with the attainment of a rapid and uniform rotation. In the first case the relation of the horizontal to the vertical component of the earth's magnetism must be ascertained; in the second, a disturbing inductive effect is produced by the magnetism of the needle, which must be artificially eliminated. The last method, the rotation of the inductor about a vertical axis, is the one adopted by the British Association, and their measurements possess greater simplicity and accuracy, from the fact that the process is independent of a knowledge of the earth's magnetism. Other defects are, however, very perceptible, and as the question arises whether and in how far the arranged execution of Weber's $\frac{\text{earth's-quadrant}}{\text{second}}$ by the British Association is a solution of this question, it will be necessary to consider the subject in detail.

In order, by aid of a co-efficient of correction, to eliminate the currents induced by the needle, the magnetism of the latter was made very weak—a condition which, it is probable, has never existed in similar tests. The magnet was a steel ball, of a diameter very nearly 8 millimetres, and a mass therefore of about 2 grms., and this unfavorably shaped mass was not magnetized to saturation. In fact, a reference to the figures stated in the Report of the British Association * will prove that the magnetism of the ball was less than that which may be communicated to a common needle weighing 0·1 grms. This circumstance will explain why a single fibre of silk 8 feet in length was necessary in order to reduce the torsion to a minimum. To this tiny magnet was united a mirror 30 millimetres in diameter on a metal wire 0·25 metres in length, affording therefore a surface of 14 sq. centimetres for air-currents. That the moment of inertia of these attachments could not have been small, is evident from the fact that the oscillating period of the system was more than 7 seconds, while that of the needle alone would have been about 1·5 seconds.

The British Association Reports give us only average values, deduced from many observations; we are therefore deprived of the data for determining any irregularities which may have been caused by the feeble magnetism of the needle. But even these results present large differences.

Thus resistances found by deflections in opposite directions differ from each other as much as 8 per centum,† which is equivalent to an inequality of 20—30 divisions of scale in the deflections to the right and left.

The intimation of Mr. Jenkin ‡ that the differences originated in an unequal or one-sided influence of the fibre is not admissible, for a torsion of such considerable influence in a fibre of such length cannot have existed.

The mean values taken by pairs reduce the differences to 1·4 per centum, but they still premise either errors of adjustment or in reading off the scale, to account for their presence.

If, therefore, we find such irregularities in the mean values of half-hourly observations (from which extraordinary deviations ‖ have even been excluded), if, further, the uniform rotation was in

* 1863, p. 172. † *B. A. Rep.* 1864, p. 350; *Pogg. Ann.* CXXVI, 386.

‡ *Pogg. Ann.* CXXVI, 387; ‖ *B. A. Rep.* 1863, p. 174.

all respects satisfactory;* then other unknown, but important sources of error must have been present; and it is not improbable that they are to be sought in the feeble magnetism, and perhaps the spherical form, of the magnet.

Another matter is, however, to be considered. Though the experiments were carried on with much intelligence, and though the theory of the corrections as stated is a model of completeness and elegance, one point is not at all approached. The stand on which the inductor rotated consisted of "strong brass frames," which, as may be seen from the drawings,† formed closed circles. We are nowheres told whether the currents induced in these stable portions of the apparatus by the rotating conductor were inconsiderable; nor are we told why they were assumed to be so. This would, it is true, be most difficult, perhaps impossible, to prove by actual experiment, but on this very account the proximity of these masses of metal is calculated to awaken distrust.

I will mention finally an objection originating with W. Siemens against the practice of deducing from the length of the wire, the mean diameter of the coils.‡ I have convinced myself that with wires whose section amounted to as much as 4—5 sq. mm., the practice is entirely reliable, but in the present case where the wire is but about 1 sq. mm., I dare not venture an opinion.

From a compilation of their separate results‖ this commission announces a probable error in their final conclusion of 0·08 per cent. The skill, labor and care which would detect so trifling an error, springing from pure accidental sources deserves the fullest recognition, but the unit they have established can receive no acceptance from physicists, until the absence of constant sources of error has been proven. To this end, perhaps, a more detailed publication of the methods and materials of their observations might be of service; and this is, from the fundamental character of their research, much to be desired. As it is, however, the labor of the commission is a classical one, and their theoretical and practical observations in the determination of absolute resistance are of the greatest value to science.

In the same way I shall next endeavor to view the third method by which the following results have been obtained, as regards its difficulties. A quantitative estimate of these difficulties seems,

* *B. A. Rep.*, 1863, p. 120. † *ibid.* p. 164.

‡ *Pogg. Ann.*, CXXVII., 333.

‖ *B. A. Rep.*, 1864, p. 350. *Pogg. Ann.*, CXXVI., p. 386.

too, not out of place, in view of the fact that existing opinions concerning the exactness of absolute resistance tests widely differ.*

Absolute resistance may be determined from observation, not regarding co-efficients of correction by aid of the following formula:—

$$w = \frac{8\, s^2\, r^2\, t,\ \text{log. nat.}\ \frac{a}{b}}{\kappa\left(a\sqrt{\frac{a}{b}} + b\sqrt{\frac{b}{a}}\right)^2}.$$

I will assume that the errors of these separate magnitudes have been determined, to within the following fraction of the whole magnitudes, viz:—The coil surface of the inductor s, to within $\frac{1}{2000}$. The intensity of the earth's magnetism to within $\frac{1}{1000}$. Duration of oscillation t to within $\frac{1}{3000}$. Moment of inertia κ to within $\frac{1}{750}$; and that the deflections on the scale shall be correct to within 0·2 mm., while in our experiments their values were 370 and 225 mm. The error then of a single observation in which all the single values should add up most unfavorably, would amount to $\frac{2}{3}$ per cent. According to the calculation of probabilities the error would amount to $\frac{1}{3}$ per cent. I call especial attention to this possible maximum, since according to my results the B. A. unit is almost 2 per cent. too large.

A very considerable portion of the above mentioned error arises from the uncertainty of determining the intensity of the earth's magnetism. From this it follows that a successful determination of absolute resistance, can only be made with the aid of the most perfect instruments for measuring intensity; such, for instance, as those now in possession of this University. Where these aids are not to be had, another method, for example the first, might give more accurate results.

With reference to the actual execution of the measurements a few points deserve mention for the sake of accuracy.

Two sets of Siemens' units, each of 4 units, especially made for Dr. Siemens' were at hand. The resistance of the circuit (inductor and galvanometer) was brought to nearly the same amount. Before and after every absolute test the last was compared with Siemens' units. Especial labor was bestowed in the determination of the intensity of the earth's magnetism. Two determinations of this

* *Pogg. Ann.*, CXIII., 310–11.

factor made during the progress of the observations (6 days), after reducing to the same level the instruments of variaties, gave very close results, the difference being less than 0·02 per cent. M. Riecke carried out the observations of variations during the measurement of intensity as also during those of resistance.

The periods of time were measured upon the clock of the University, the weights used were a set of Fortius, the tests of length were made with a platinum metre in possession of the department of engineering, and the graduations of the paper scale used were subsequently compared with each other.

The comparisons of the resistances was accomplished by simple branching of the current in a double coiled galvanometer; but the currents employed were not as usually used, hydro-electric, but short ones induced by Weber's magneto-inductor.

The employment of weak induced currents effectually prevented any heating effect: and the alternation of the direction of the currents eliminated at once all effects of any possible existing thermo-electromotive force. On account of the slight inequality of the resistances to be compared a 0·1 Siemens was interpolated.

It appears to me to be indisputable that such a combination of induced currents, with methods adapted to compare resistances, must offer great advantages in point of convenience as well as in accuracy.

As a proof of the care and exactness with which Siemens units are adjusted, I may mention that the two latter ones, at the temperature marked upon them, should have a proportion 1·00044. From comparisons with a third set, I found that proportion to be 1·00050, 1·00046, 1·00055

The results of the observations consist in three determinations of Siemens unit according to absolute measure. It was found that—

$$1 \text{ Siemens'} = 0{\cdot}9705 \ \frac{\text{earth's quadrant}}{\text{second.}}$$

$$1 \text{ Siemens'} = 0{\cdot}9608 \quad \text{“}$$

$$1 \text{ Siemens'} = 0{\cdot}9713 \quad \text{“}$$

So that the mean value of the Siemens' unit is equal to 0·9705 $\frac{\text{earth's quadrant}}{\text{second}}$, or equal to 9705000000 $\frac{\text{mm.}}{\text{sec.}}$. M. Herman Siemens was kind enough to compare the Siemens' with the B. A. unit (the property of Dr. Weber and Dr. Brix), the result was—

$$1 \text{ B. A. unit} = 1{\cdot}0493 \text{ Siemens};$$

which value, with the necessary reduction, agrees almost exactly with Mr. Jenkin;* so that 1 B. A. unit = 1,0184 $\frac{\text{earth's quadrant}}{\text{second.}}$

As important as it is in practical tests of resistance to know the absolute value of the Siemen unit, so great also in the measurement of currents is the necessity for an accurate knowledge of the constant introduced by M. Weber, the electro-chemical equivalent of water. This permits of absolute measurement of currents with the voltametre, but is only exact to within one per cent. This determination was likewise undertaken and carried out; but unfortunately the toilsome task was fruitless, owing to the local influence exerted by a brass screw in the damper of the tangent instrument, which was not noticed until too late, and the disturbance created was too great to be eliminated.

ON A METHOD OF FIXING, PHOTOGRAPHING AND EXHIBITING THE MAGNETIC SPECTRA.

By Alfred M. Mayer, Ph.D.

The figures produced in iron-filings, when these are set in momentary vibration on a surface placed over a magnet, have received considerable attention from natural philosophers. The geometrical discussion of these spectra made by Lambert, Roget and others, have developed their symetrical properties and thereby have evolved the law† of that action which emanates from the magnet. De Haldat has used them as a means of exploring the distribution and intensity of the effect of juxtaposed magnets variously arranged. But, above all, have the researches of Faraday and W. Thomson on "the magnetic field" and on "the lines of magnetic force" given to these spectra—even when merely regarded as conventional symbols—an importance which has been fully shown, especially by Faraday, who was guided by their consideration to some of his most important discoveries. They have thus risen to so high a theoretical importance that a method which will fix them without danger of distortion, photographically repro-

**Pogg. Ann*, CXXVI., 382.

†See a neat "Démonstration par le calcul des courbes magnétiques de la loi de l' inverse du carré de la distance," by M. Cellerier, published as a note on p. 592, Vol. I., of De la Rive's Traité d' Electricité.

duce them, and readily serve to exhibit them to the largest audiences, will, I imagine, be acceptable to both investigators and lecturers.

The only process of fixing these spectra, known to me, is that practiced by De Haldat and Faraday, which, however, is but an application to the magnetic spectra of the method previously invented by Savart for preserving the Chladni figures of vibrating plates. In this process the spectra, produced in the usual manner either on glass or card-board, have pressed upon them a sheet of paper coated with mucilage to which the filings adhere. In this operation of the transfer many particles are deranged from their positions and the figures are yet more distorted by the shrinkage of the wet paper, and are therefore not fit to serve in measures of precision; while the impressions cannot be exhibited with much more facility than the originals.

My process is as follows: a clean plate of thin glass is coated with a firm film of shellac, by flowing over it a solution of this substance in alcohol,* in the same manner as a photographic plate is coated with collodion. After the plate has remained a day or two in a dry atmosphere it is placed over the magnet, or magnets, with its ends resting on slips of wood, so that the under surface of the plate just touches the magnet. Fine iron-filings, produced by "draw-filing" Norway iron which has been repeatedly annealed, are now sifted uniformly over the film of shellac by means of a fine sieve. The spectrum is then produced on vibrating the plate, by letting fall vertically upon it, at different points, a light piece of copper wire. The plate is now cautiously lifted vertically off the magnet and placed on the end of a cylinder of pasteboard, which serves as a support in bringing it quite close to the under surface of a cast-iron plate (1 ft. diam., $\frac{1}{2}$ in. thick) which has been heated over a large Bunsen flame. Thus the shellac is uniformly heated and the iron filings, absorbing the radiation, sink into the softened film and are "fixed."

I generally allow the heat to act until the metallic lustre of the filing has disappeared by sinking into the shellac, and the film appears quite transparent. This degree of action is necessary when photographic prints are to be made from the plate, but when they are to be used as lantern slides I do not carry the heating so far.

* The shellac dissolved in strong alcohol is allowed to stand a week or more, and the clear supernatant solution is then decanted.

After the plate has cooled, it is allowed to fall upon its ends, on a table, so that any filings that have not adhered may be removed.

A short experience will give the proper strength of shellac solution to obtain a film so thick as *just to be sufficient to hold the filings*, and the requisite amount of heat to firmly cement them without injuring the transparency of the film.

The plates can now serve (1) for the most accurate measures upon the magnetic field; (2) for a photographic positive, which, in the printing-frame will produce the lines in white upon a dark ground, giving most beautiful and distinct impressions;* (3) or, if it is required to exhibit these figures to an audience, the plates are provided with glass covers, kept from touching the spectra by intervening slips of card-board, and there result "slides," in every way fit for giving a fine exhibition when the images are projected upon a screen. I have thus obtained images, clear and sharp, of over 12 feet in diameter.

By this process many plates have been produced,† showing the action of single magnets of various forms, and of juxtaposed bars; as well as the effects of electric currents led by wires through holes drilled in the plates. Those exhibiting the inductive action of magnets on bars of soft iron and the interaction of magnets and electric currents are peculiarly interesting. An approximate representation of the resultant line of the terrestrial magnetic action has been obtained by magnetizing *equally tempered* steel discs of from 2 to 3 inches, and even more, in diameter. The magnetic axis, or axes, of these discs being *predetermined* by making them the continuation of the axes of powerful electro-magnets whose poles are conical projections with slightly rounded apices. The arcs of the great circles, including the terrestrial magnetic poles, having been calculated, the axes of the electro-magnets are inclined at that angle, while the steel disc is held close to their poles. On passing the current the disc is magnetized, and we have an approximate representation of a section of the earth's magnetic effect. These results when viewed as photographic prints, or, as exhibited by the lantern, are as beautiful and instructive as to appear to me to warrant this somewhat formal description of the process of their production.

* Photographic prints from a series of eight of these plates I have presented to Harvard College, American Academy of Sciences, Sheffield Scientific School, Columbia College, Stevens Institute of Technology, Hoboken; Lehigh University, Pa.; American Philosophical Society, Franklin Institute, Peabody Institute, Baltimore; Smithsonian Institute, Chicago Academy of Sciences, and to the University of Virginia, where they can be examined by the readers of this paper.

† Many of these are 16 inches long by 10 inches wide.

Bibliographical Notices.

Report of Committee of the Trustees of the Rensselaer Polytechnic Institute, concerning the System of Instruction, with proposed modifications.

In obedience to a peculiar demand of American civilization, the minds of educators have been largely engrossed the past ten years with the subject of Technical education, in connection with modern literature, as opposed to what is usually comprehended under the term of a strictly "classical education."

While a great deal can be said on both sides as to the mental training given in each system, apart from any material considerations, there is no question that the advocates of the New Education are rapidly gaining ground, as shown by the establishment of technical schools throughout the States, either independent or attached to the older colleges. The pioneer school in this new education, as is well known, is the Rennselaer Polytechnic Institute, at Troy, established primarily for the student of natural science, but rapidly expanding in a technical direction, it has become the leading school in this country—a proud distinction that more than one competitor is endeavoring to wrest from it. The Troy school, with no endowment, has won its position through exacting the highest requirements from its students, and combining with a rigid theoretical instruction a large amount of actual practice. It has struggled through difficulties that would have deterred from further effort almost every other institution, and it is to the credit of its trustees and faculty that they have brought it so nearly to a perfect success.

In furtherance of the desire of the trustees to increase the usefulness of the institution, a committee from their number was appointed last March to examine into the present course of instruction, and report if it were desirable to modify it in any particulars, in order that it might conform to the most advanced state of Technical Science. This committee (consisting of Messrs. E. Thompson Gale, A. L. Holley and C. E. Dutton) have just issued their report, which is certainly one of the most valuable contributions to the cause of technical education ever published in this country. Without restricting their researches to the opinions of professional instructors in various portions of the United States, they have obtained ideas

from those actually engaged in practical life. These letters are placed in an appendix, and are from such men as Messrs. A. S Hewitt, S. M. Felton, Robert Briggs, Wm. Sellers, J. Vaughn Merrick, Gen. McClellan, Gen. J. G. Barnard, &c., &c. The consequence of this business-like procedure, the committee had before them an amount of valuable opinion based upon experience, that enabled them to point out the wants of the Institute with a confidence in the result obtainable in no other way.

After some preliminary remarks, defining the position of technical schools (as typified in the Institute) in relation to the needs of young men after graduation, the report gives an outline of the course of instruction adopted in foreign technical schools, selecting for illustration that of "Carlsruhe," noted for its comprehensiveness. Until government thinks it to be a duty to undertake the higher education of its citizens, it is impossible for any school in this country to attain the perfection of a German school. In Germany education is a system, one school depending on another—a harmonious gradation carrying the pupil from the public or common schools up to the university or polytechnic school—the one almost purely literary, the other purely scientic or technic.

While lamenting that we never in this country can attain the educational harmony of Germany, we can do much in localities, in so far as local governments can control local schools, and make them to be operated as part of a progressive educational system. In this view, the committee have recommended in their report that the trustees should request the city authorities of Troy to co-operate with them in making the High School a preparatory school for the Institute, as well as being as it is now, merely a preparatory school for college. It must be remembered that technical schools require as much preparation in the student as do colleges, and in some particulars more. It is impossible for a technical school to pay that attention to literary attainment which every young man should possess to a certain extent, and which can only come from a preparatory school in full accord with the higher education which is to follow.

To touch upon all the topics so ably discussed in this report would hardly be possible in a brief notice. Careful examination is bestowed upon all the leading branches of a scientific education, with the deductions resulting therefrom. Special emphasis is given to the importance of more than text book instruction on steam and its appliances, since there is no branch of the engineer's profession